FLOODED ISLANDS

PRE-FEASIBILITY STUDY REPORT

PREPARED FOR:

CALIFORNIA DEPARTMENT OF WATER RESOURCES

FOR SUBMITTAL TO:

CALIFORNIA BAY-DELTA AUTHORITY

JUNE 30, 2005

PREPARED BY:

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HANSON ENVIRONMENTAL, INC.

FLOODED ISLANDS

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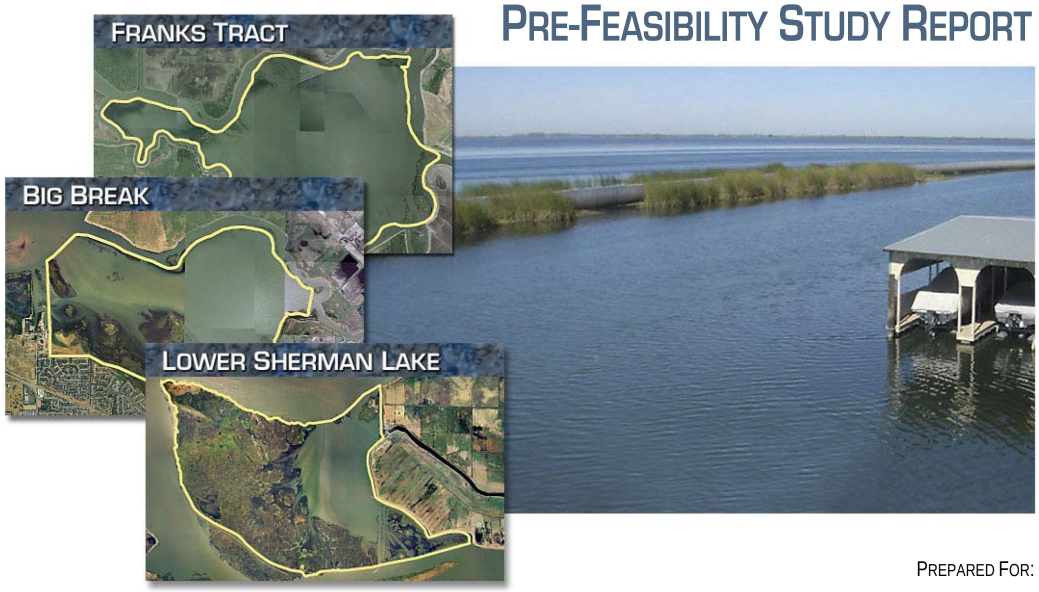

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Section	Page

Tables (continued)

Exhibits

TABLE OF CONTENTS

Section | Page

Exhibits (continued)

TABLE OF CONTENTS

Section Page

Exhibits (continued)

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1 INTRODUCTION

1.1 STUDY PURPOSE

After circulating the Administrative Draft and Draft Flooded Islands Feasibility Study Report, it was decided that in order to better reflect the conceptual nature of this document, the title would be changed to Flooded Islands Pre-Feasibility Study Report. The Flooded Islands Pre-Feasibility Study Report (Pre-Feasibility Study or study) was initiated by the California Department of Water Resources (DWR) to develop and evaluate site concepts, individually and in combination, for their ability to benefit water quality (e.g., reducing salt trapping and mixing), the ecosystem (e.g., increase habitat values for fish and wildlife, including protected species, and inhibit invasive plants), and recreation (e.g., retaining boat access, maintaining sport fisheries, improving amenities). This study is important because modifications to flooded islands could significantly improve water quality during drier times of the year while enhancing Delta ecosystem values and recreation opportunities. This study was conducted from a grant from the California Bay-Delta Authority (formerly CALFED).

1.2 PROBLEM STATEMENT

The Sacramento-San Joaquin River Delta (the Delta) is a major water supply, recreation, and ecological resource in the state. Exhibit 1-1 is a regional map of the Delta and provides the legal Delta boundary. The estuary system functions as the hub of an extensive network of waterways that flow through the north and central regions of California. Although the Delta is essentially a freshwater system, water levels and flow velocities are subject to tidal influence and fluctuating salinity because of its relatively low elevation. The Delta supplies drinking water for two-thirds of the California population and irrigation water for over 7,000,000 acres of agriculture.

The Delta has been extensively altered beginning in the late 1850's with the passage of the Swamp and Overflow Land Act and influx of population into California because of the Gold Rush. Ecologically, the most significant change has been the loss of intertidal landforms, wetlands, and shallow shoals that support diverse plant communities and wildlife habitats. In addition, the reclamation of islands to agriculture uses resulted in extensive subsidence and much deeper landforms than the surrounding waterways. Thus, when levee breaks occur, newly flooded islands are much deeper than prehistoric conditions. The flooded islands are dominated by open water homogenous habitats with more limited ecological value than historic tidal marsh, and some environmentally damaging characteristics. Wind-driven waves and boat wakes cause erosion on remnants of tidal marsh and levees of adjacent islands. The open water areas of the flooded islands provide habitat for mostly nonnative fish and are dominated by invasive nonnative aquatic plants, most notably Brazilian waterweed (*Egeria densa*). The open water and nonnative fishery provides recreational opportunities; however, this value has been somewhat reduced because of the nuisance effects associated with the presence of Egeria (see section 2.4.1).

Salinity within the Delta are primarily a function of the location of high-salt content ocean water with daily tidal action, freshwater inflow to the Delta, and the hydrodynamic processes in the Delta channels that govern channel flow conditions and mixing of water sources with variable salt content. During winter and early spring, freshwater inflows to the Delta are usually above the minimum required to control salinity intrusion into the Delta. However, at least for a few months in summer and fall of most years when freshwater inflows to the Delta have declined, Delta salinity conditions must be carefully monitored and controlled. Broad-scale salinity control actions are taken in the Delta because its channels are at or below sea level and unless repelled by continuous seaward flow of fresh water, seawater can advance into the western Delta and adversely affect compliance with water quality objectives and beneficial uses provided by Delta freshwater resources. The effects of ocean tides on Delta hydrodynamic conditions are modified by freshwater inflow and diversion rates.

Delta export pumping occurs at several locations: the Central Valley Project (CVP) Tracy Pumping Plant and the State Water Project (SWP) Banks Pumping Plant in the southern Delta and account for the large majority of Delta exports (i.e., about 5 million acre-feet annually). Comparably, much smaller volumes of water are diverted by Contra Costa Water District (CCWD) at its Rock Slough and Old River intake facilities in the southern Delta, and the North Bay Aqueduct pumps at Barker Slough.

The three flooded islands are all located in the central and western Delta and are routinely exposed to a wide range of salinity. Together they comprise an incremental portion of the overall available open water volume within the western Delta that is subject to tidal exchange. Consequently, the flooded islands contribute incrementally to the distance that high-salt content seawater can enter into adjacent Delta channels. Field and modeling data indicate that hydrodynamic conditions of Franks Tract in particular, may result in dramatic effects on overall salinity conditions in the central Delta.

Franks Tract is connected tidally to the San Joaquin River via the False River channel that forms the northern edge of the island. During a four-month experiment in 2002, tracking of tidal flows with drifters and salinity measurements detected that high-salt content water entered Franks Tract during the flood tides. However, the data indicated that saline water was retained in Franks Tract and less dense freshwater near the water surface flowed back into False River during the ebb tide flow. The data also indicated that saline water entering Franks Tract through the largest existing levee breaches near the west side then mixed within the island. This process is considered an important factor in the hydrodynamic forces that may alter salinity conditions in adjacent Delta channels and the central Delta overall. The data suggests that net reverse flows in Old River draw water from Franks Tract and can thereby result in higher salinity conditions in flows moving into the southern Delta than would otherwise occur if Franks Tract did not trap the salty water.

A suite of complex physical phenomenon is involved with the salinity intrusion and mixing occurring at Franks Tract. Geometry and location of levee breaches play a role in that the breaches located along the western side of the island are within the distance that routing tidal salinity intrusion can occur. Tidal action itself, in terms of the tidal wave propagation that varies over time and by location, also is an important factor in mixing force dynamics. The geometry and size of the levee breaches create a high velocity nozzle effect that facilitates transport and mixing of saline water with freshwater within the island. Bathymetry (i.e., shape, depth, length) of the open water segment, hydraulic residence time of water within the island, and presence of dense vegetation growth may also be an important factor in the mixing characteristics of saline and freshwater sources.

Additional information regarding the Delta is available in the Baseline Report (EDAW 2005), which provides a detailed description of existing conditions at the study areas. A photographic representation of existing remnant levee and habitat conditions at Franks Tract is provided in Exhibit 1-6. A conceptual model of the Flooded Islands Pre-Feasibility Study is provided in Exhibit 1-7. A generalized graphical explanation of Delta salinity transport processes is detailed in Exhibit 1-8.

1.3 OBJECTIVES

The following objectives for the Feasibility Study were first proposed in the 2001 grant application to CALFED for the Feasibility Study, and were modified in February 2005 in response to preliminary results of modeling efforts and new information, as outlined in *Flooded Islands Feasibility Study Technical Memorandum #2* (2005). The CALFED proposal included the following four objectives; analyses and revisions follow each of the objectives.

Original Objective 1: Evaluate the feasibility of habitat diversification approaches for Lower Sherman Lake, Big Break, and Franks Tract with the objectives of restoring ecosystem values, improving water quality conditions for water supply, and enhancing recreation and other social values of the flooded islands.

Discussion: This objective relates to the process of evaluation and is being achieved through a review of published literature, discussions with experts, hydrological modeling, and development of matrices that qualify and compare the effects that various conceptual alternatives (see Conceptual Alternatives Report, to be released May 1, 2005) may have on the ecosystem and recreational activities. Key issues that are currently being examined include carbon cycling and primary productivity; mercury methylation, salinity, dissolved oxygen, and other water quality factors; temperature and residence time; habitat variability and native vegetative communities; native and sport fisheries; invasive species management and control; and recreational facilities and boating access.

Preliminary modeling and data collection suggest that modifications at Franks Tract have a high potential for beneficial water quality effects. Site improvements at Big Break and Lower Sherman Lake are not expected to significantly improve water quality; however, these locations provide opportunities for achieving part of the habitat restoration objective while assisting the landowners (East Bay Regional Park District at Big Break and California Department of Fish and Game at Lower Sherman Lake) with habitat improvement goals. Ongoing study efforts include continuing to work with landowners and other knowledgeable and interested parties to help determine project effects on recreation and the ecosystem. Overall, preliminary investigations indicate that modifications at Franks Tract may achieve all project goals to varying degrees, while Big Break and Lower Sherman Lake actions may provide restored ecosystem values and/or recreation enhancement. Accordingly, it may be desirable to implement restoration and/or recreation actions at Big Break and Lower Sherman Lake to maximize and balance benefits among the three sites. Additionally, restoring tidal marsh at adjacent subsided islands may be a more cost effective and sustainable approach to diversifying habitat in the general study area.

Revised Objective: Evaluate the feasibility of habitat diversification approaches for Lower Sherman Lake, Big Break, and Franks Tract <u>and adjacent areas</u> with the objectives of restoring ecosystem values, improving water quality conditions for water supply, and enhancing recreation and other social values <u>at one or more</u> of the flooded islands.

Original Objective 2: Develop and evaluate innovative and cost-effective Delta tidal marsh restoration concepts that re-create dendritic channels and provide ecological benefits for native plants, fish, and wildlife, and impede the success of invasive, nonnative fish and aquatic plants.

Discussion: Preliminary discussions suggest restoration of dendritic channels at the project sites may be feasible by (1) repairing levees adjacent to Franks Tract and creating adjacent tidal marsh habitat, (2) using dredge and/or borrow material to create islands within one or more of the flooded islands, and (3) restoring tidal marsh conditions to subsided (but not flooded) islands adjacent to one or more of the three islands (e.g., Jersey Tip, Mayberry Point, Quimby Island).

Ecological benefits to native plants and wildlife are expected, given that new islands would be vegetated with native plants, which would provide habitat for native wildlife. Because of the limited knowledge regarding habitat use and importance of the specific study sites to native fish, the effect on native fish, either beneficial or adverse, cannot be ascertained without additional monitoring. However, given that the existing conditions provide a beneficial environment for nonnative fishes and have resulted in the decline of native fish species, native habitat restoration is likely to benefit native fishes, although to an unknown extent.

Invasive, nonnative fish and aquatic plants as they exist at the flooded islands are a problem for which there are no known viable methods of eradication. Although there are mechanical and chemical techniques for limiting invasive aquatic plant species, it may be financially and environmentally infeasible to implement a long-term control program. New invasive plant and fish species may yet colonize the study sites. In addition, a few of the invasive species are considered desirable game fish species (e.g., striped bass, catfish). Because their habitat requirements overlap with less desirable species, it may not be possible to selectively inhibit some invasive species while encouraging others. Similarly, some native species and invasive plant species share similar habitat requirements; for this reason, it would be difficult to encourage some native species while impeding the success of some invasive species. Because the study sites are unnatural ecosystems, it is difficult to design a restoration project that will clearly benefit native species. When designing restoration projects, it is best to attempt to replicate highly functioning native ecosystems to the extent feasible in order to limit nonnative species.

Revised Objective: Develop and evaluate innovative and cost-effective Delta tidal marsh restoration concepts that re-create the dendritic channels <u>or other desirable environmental conditions</u> and provide ecological benefits for native plants, fish, and wildlife, and impede the success <u>of undesirable </u>invasive, nonnative fish and aquatic plants.

Original Objective 3: Evaluate restoration of shoreline levees with strategically located openings to beneficially alter the salt-trapping and mixing characteristics of the three flooded islands while retaining tidal flow to the island interiors.

Discussion: Preliminary modeling results suggest that repairs of remnant levees and/or installation of operable gates at strategic locations at Franks Tract and adjacent channels have a high potential for beneficial water quality effects. Site improvements at Big Break and Lower Sherman Lake are not expected to significantly improve water quality.

The magnitude of the cost of CALFED actions is becoming an increasing concern to many CALFED stakeholders. As a result, the potential project alternatives need to carefully consider the benefits and the corresponding costs of these alternatives and develop cost-effective recommendations for consideration and implementation. The phasing of a project and/or a pilot approach should therefore be considered.

Revised Objective: Evaluate <u>cost-effective</u> restoration <u>and modification </u>of shoreline levees and adjacent channels ~~with strategically located openings,~~ ~~to beneficially alter the salt-trapping and mixing characteristics of~~ <u>to one or more of the</u> flooded islands to improve water quality in the central and south Delta. ~~while retaining tidal flow to the island interiors~~.

Original Objective 4: Achieve concurrent resource benefits for the three flooded islands, including recreation, aesthetics, and flood control.

Discussion: Recreation, aesthetics, and flood control remain important considerations for the study. Equivalent, concurrent benefits may, however, be difficult to achieve based on initial investigations. Trade-offs between different benefits may arise at a site. For instance, to improve water quality and habitat conditions, preliminary designs being considered may obstruct the existing boating paths through Franks Tract. To preserve boating access, it may be possible to install lock(s) and gate(s) and to dredge channels for boating access through Franks Tract. Creation of islands would provide additional habitats (e.g., edge habitat) that are preferred for fishing and hunting activities. New beach areas may also be created to increase recreational opportunities. However, the long-term sustainability of created islands, especially in Franks Tract, is in question because of subsidence and wave generated erosion.

Implementation pursuant to the feasibility study is not expected to have major aesthetic consequences. Preliminary designs have included only infrastructure (e.g., locks, flood gates) and modifications (e.g. vegetated islands) that are commonly found in the Delta. It is not clear if any design would improve the aesthetic quality at the study sites. It is likely that the existing expansive viewshed (e.g., open water and occasional island) would be maintained.

An increase or reduction of flooding risk is not expected. However, creation of habitat islands could protect adjacent levees from wave erosion, resulting in reduced maintenance. Flooding effects would be evaluated as a part of the modeling effort, and any substantial increase would cause reconsideration of the design.

Revised Objective: Achieve ~~concurrent~~ resource benefits ~~for the three flooded islands~~, ~~including~~ or maintain existing, desirable characteristics related to recreation, aesthetics, and flood control at the three flooded islands.

1.4 HYPOTHESIS

Can water quality be improved; ecosystem values for native vegetation, fish, and wildlife be restored; and recreation and other social values be enhanced by (1) altering the hydrodynamics of the flooded islands by strategically designed levees and openings, (2) restoring shallow open water to more complex tidal marsh, and (3) creating recreational beaches and other amenities?

1.5 METHODOLOGY

Before modeling exercises, it was thought that water quality goals may be achievable at any one of the flooded islands. However, following preliminary modeling runs, it was determined that water quality improvements are much more effective at Franks Tract than at Big Break and Sherman Lake. Franks Tract is located at the eastern edge of the late summer and fall salinity gradient, and its remnant levee configuration with numerous breaches promotes the mixing of salt water on flood tides with freshwater entering Franks Tract from the east. Furthermore, Franks Tract is contiguous with Old River and Holland Cut, the channels that convey fresh water from the northern Delta to the drinking water export/diversion facilities in the south Delta. As a result, it was decided not to further model and evaluate levee modifications around Big Break. It is possible; however unlikely, that future modeling runs could show that reconfiguration of Big Break may change salinity in the south Delta.

At the beginning of the study, several site concepts were considered, these are: (1) modification of remnant levees, (2) restoring natural landforms, and (3) modifying channels to restrict salt trapping and mixing while retaining tidal influence and recreational access to the flooded island interiors. Additional concepts, such as operable gates, pocket beaches, and pocket marshes, were added later in the study process.

As part of the study, a Conceptual Alternatives Report was prepared (NHI 2005) to identify and screen a broad range of opportunities for modifying flooded islands and adjacent lands and waters to achieve the 3 overriding project goals (enhance ecosystem values, reduce salinity at the pumps, and improve recreational and other social amenities). A pre-modeling screening tool was developed to evaluate various water quality improvement elements and their potential impact on water quality, ecosystem, and recreational parameters. The report separately identified and evaluated options for achieving each of these objectives. The options were organized as separate elements, each of which could be implemented independently or in combination with other elements.

Following preliminary modeling, multi-dimensional numerical modeling was developed specifically for this pre-feasibility study to increase the resolution of the modeling code to better represent physical and chemical properties that influence the transport and mixing within Franks Tract (RMA 2005). Using this modeling framework as part of this pre-feasibility study, two basic means of changing the salinity transport characteristics in the central Delta were developed, these are: (1) reducing mixing of salinity into Franks Tract (west side solutions), and (2) reducing the exchange of salt into the freshwater corridor (east side solutions). Interestingly, both approaches reduced salt concentrations at the export facilities. Therefore, based upon this framework, the 3 methods for controlling movement of saltwater in the Delta are: (1) reconstruction of levees around portions of the perimeter of Franks Tract, resulting in a reduction of the exchange between the channels and the large open water areas; (2) construction of permanent or seasonal barriers in Delta channels, and (3) construction of operable gates across Delta channels or in levee breaches that convey water from channels into flooded islands.

During this time, a menu of ecosystem and recreation options were further developed and evaluated based upon a number of criteria. Recreation elements were refined through discussions with local stakeholders (primarily Bethel Island residents and business owners) and the Department of Parks and Recreation (Franks Tract landowner). Potential tidal marsh restoration sites were identified and evaluated based on the multiple criteria: (1) depth of flooded area or subsidence, (2) substrate type and associated compaction factors, (3) size of restoration area and proximity to existing marsh areas, (4) potential length of edge habitat, (5) erosion risk, (6) proximity to higher-velocity channels, (7) potential for access to restored marsh via deep, Egeria-free channels, and (8) potential for topographic diversity. See chapter 3 for a detailed discussion of these elements.

A fatal flaw matrix was developed for the initial water quality alternatives that evaluated material availability, residence time in Franks Tract, and substantial recreational impacts (e.g., considerable blocking of boating access to Bethel Island). These matrices are also provided in Chapter 3. Other criteria that were assessed for the alternatives include sustainability, cost, feasibility, and ease of permitting each of the alternatives.

The Pre-Feasibility Study follows a proven resource planning model with components for baseline conditions definition, development of objectives, identification of preliminary alternatives, evaluation of alternatives against the objectives, iterative reviews of information and results, public and agency input at milestones, refinement of alternatives, explanation of conclusions, and definition of a preferred project (or projects) and pilot program with recommended next actions. Specifically, the Pre-Feasibility Study was divided into 10 major tasks, as listed below:

1. agency coordination / public outreach / project management;
2. gather data and define baseline;
3. develop and calibrate model;
4. review and confirm objectives and priorities;
5. define alternative restoration concepts;
6. model and evaluate alternative restoration concepts;
7. estimate costs of alternative concepts;
8. refine concepts and define preferred pilot program;
9. prepare monitoring and adaptive management program; and
10. prepare feasibility study report.

Many of the tasks identified above included separate reports or memoranda and were completed before or in parallel with this report (see Section 1.7, "Other Studies and Reports," below).

This Pre-Feasibility Study Report presents analyses and screening tools used in the development and evaluation of individual site concepts and combined restoration alternatives. Chapter 2 of the report includes an opportunities and constraints analysis. This analysis evaluates the primary issues, identifies uncertainties, and presents conceptual approaches for restoration. Chapter 3 describes the process of preliminary alternatives development and analysis, including the selection and evaluation of improvement elements and the formulation of preliminary alternatives based primarily on water quality modeling exercises. Chapter 4 develops and analyzes the alternatives to an additional level of detail, using an alternatives evaluation process, evaluation criteria, summary comparison, and benefit–cost analysis. Finally, Chapter 5 presents recommendations, including guidelines for pilot programs. Chapter 5 also identifies next steps, tentative scheduling, and environmental compliance and permitting requirements.

Because of the preliminary nature of the Pre-Feasibility Study, a wide range of possible future actions to achieve a variety of objectives were identified; these actions will not be approved for implementation with the completion of this study. Rather, actions identified in this study will need further consideration to determine if projects should be proposed for design and construction. As such, the completion of this pre-feasibility study is exempt from the California Environmental Quality Act (CEQA), in accordance with Section 15262 of the State CEQA Guidelines. CEQA compliance would be required at the time restoration projects are proposed for approval and implementation. Because of the likely involvement of Federal agency approvals and/or funding, compliance with the National Environmental Policy Act (NEPA) would also be required for future restoration projects.

1.6 STUDY AREAS

The Pre-Feasibility Study examines restoration concepts at three locations in the Delta, referred to herein as study areas: Franks Tract, Lower Sherman Lake, and Big Break. The study areas were historically reclaimed for agriculture by constructed levees in the western and central Delta that flooded when their levees were breached (Exhibit 1-2). Mildred Island, another prominent flooded island in the Delta, was not included in this study because of its location east of the salinity gradient and subsequent lack of salt trapping potential.

The largest of the flooded islands included in the study is Franks Tract (Exhibit 1-3). Franks Tract encompasses the Franks Tract State Recreation Area, which is owned and managed by the California Department of Parks and Recreation (DPR). The western portion of Franks Tract, known as Little Franks Tract, is a 330-acre area west of the larger 3,300-acre flooded area known as Franks Tract.

The Lower Sherman Lake study area consists of three main parts: the main submerged area known as Lower Sherman Lake, another submerged island named Donlon Island, and Lower Sherman Island (Exhibit 1-4). Lower Sherman Lake and Lower Sherman Island collectively form the Lower Sherman Wildlife Area, owned and managed by the California Department of Fish and Game (DFG).

The Big Break study area consists mostly of the Big Break Regional Shoreline, which includes the flooded portion of Big Break Tract and 40 acres of upland areas along the south shore of Big Break near Big Break Road (Exhibit 1-5). Big Break is owned and managed by East Bay Regional Park District (EBRPD).

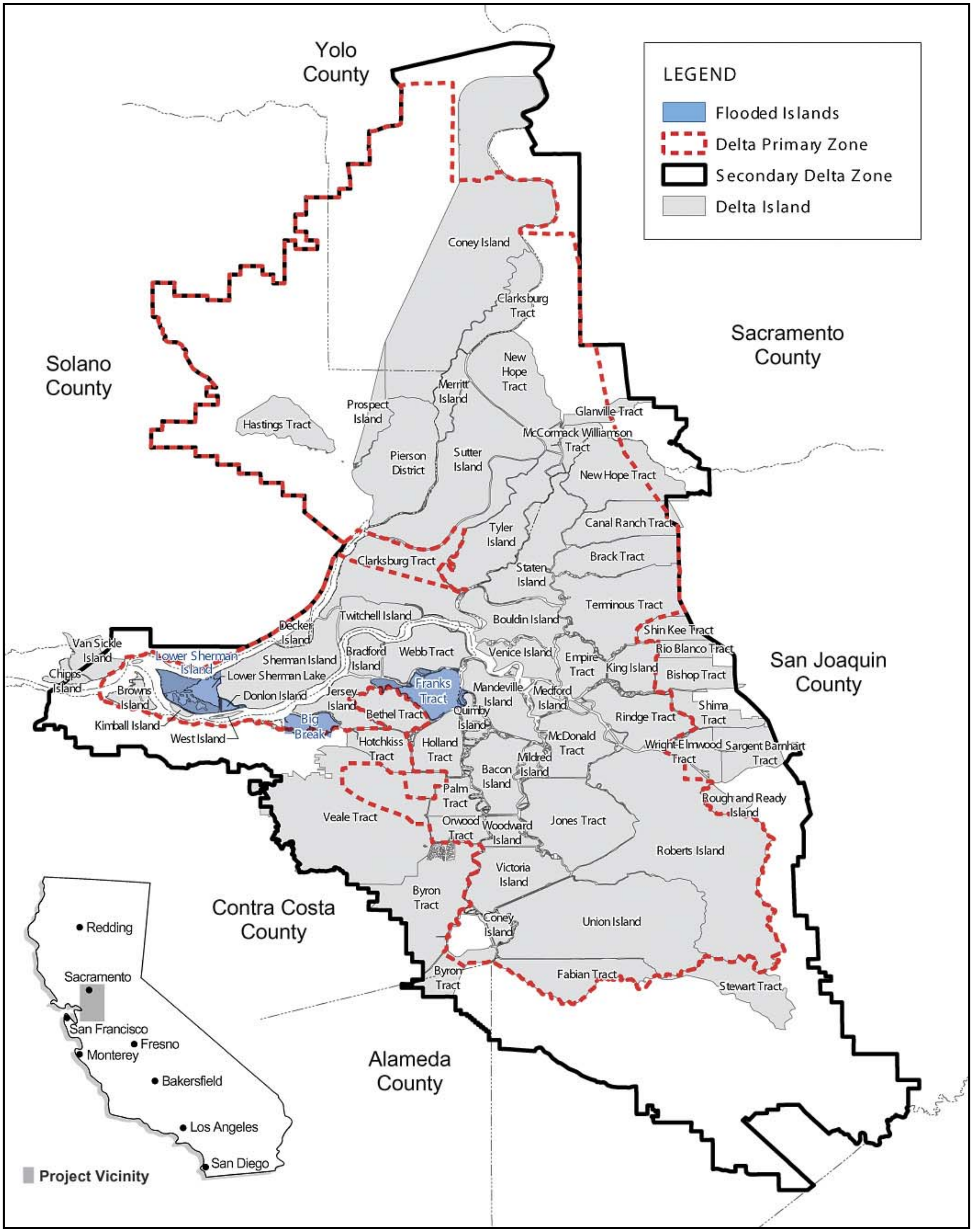
1.7 OTHER STUDIES AND REPORTS

The following documents have been produced for the Pre-Feasibility Study:

- Technical Memorandum #1: Public Outreach, Science Advisory Group, and Integration Team Process (January 15, 2005)
- Flooded Islands Feasibility Study, Baseline Report (February 2005)
- Technical Memorandum #2: Problem and Objectives Statement (February 2005)
- Model Calibration Report (May 2005)
- Flooded Islands Feasibility Study, Alternatives Modeling Report (May 2005)
- Conceptual Alternatives Report (May 2005)
- Technical Memorandum #3: Monitoring and Adaptive Management Approach for Pilot Project (May 2005)

Much of the information included in this document is based largely on review and synthesis of these documents. This document, as well as most of those listed above, is available on the DWR website located at:

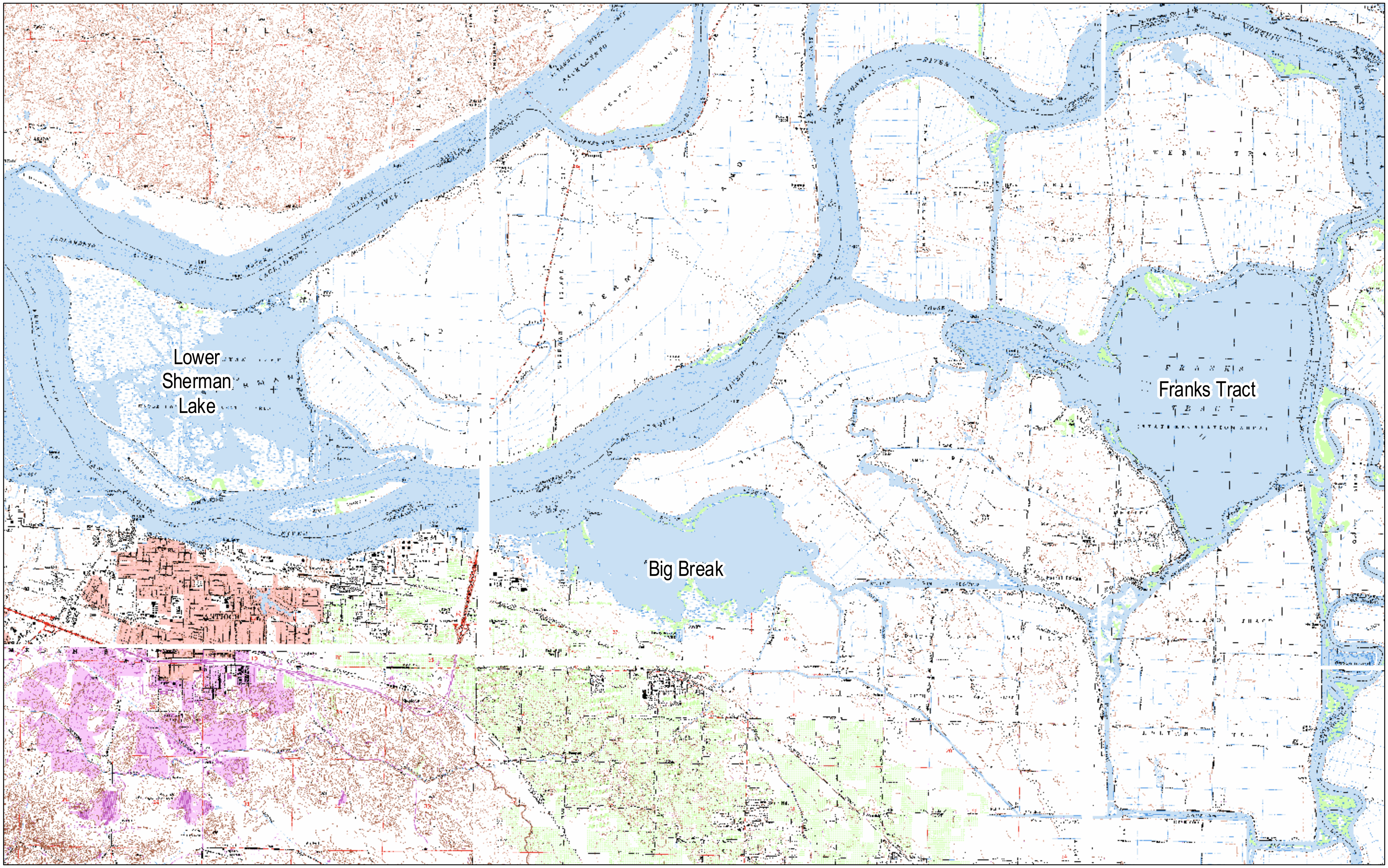
http://baydeltaoffice.water.ca.gov/ndelta/floodedislands/index.cfm



Source: DWR 2003

Regional Map

EXHIBIT 1-1



Sources: USGS Quads (Antioch North 1978, Antioch South 1980, Bouldin Island 1993, Brentwood 1978, Jersey Island 1978, Woodward Island 1978)

Study Area

EXHIBIT 1-2

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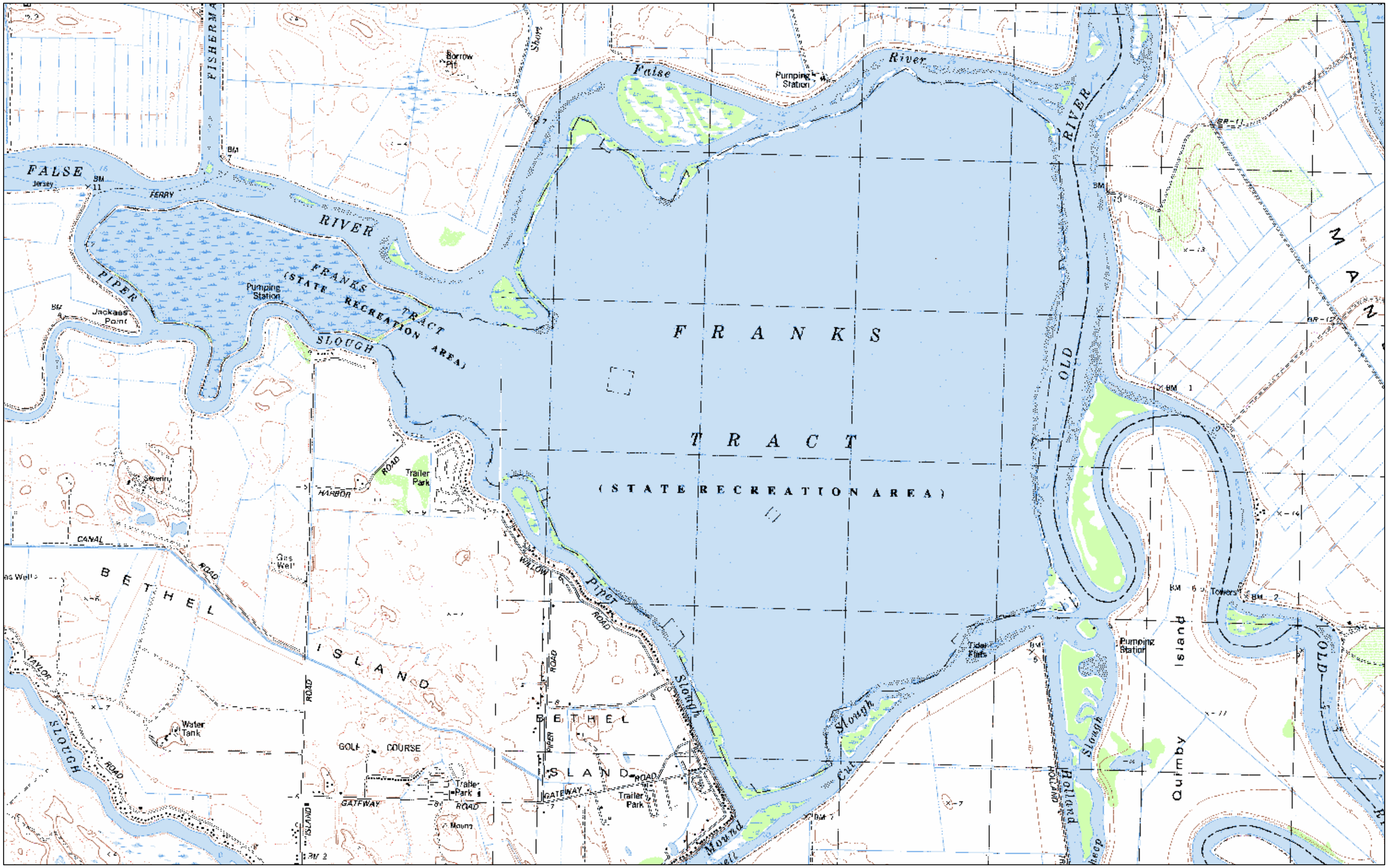

Sources: USGS Quads (Bouldin Island 1993, Jersey Island 1978)

Franks Tract

EXHIBIT 1-3

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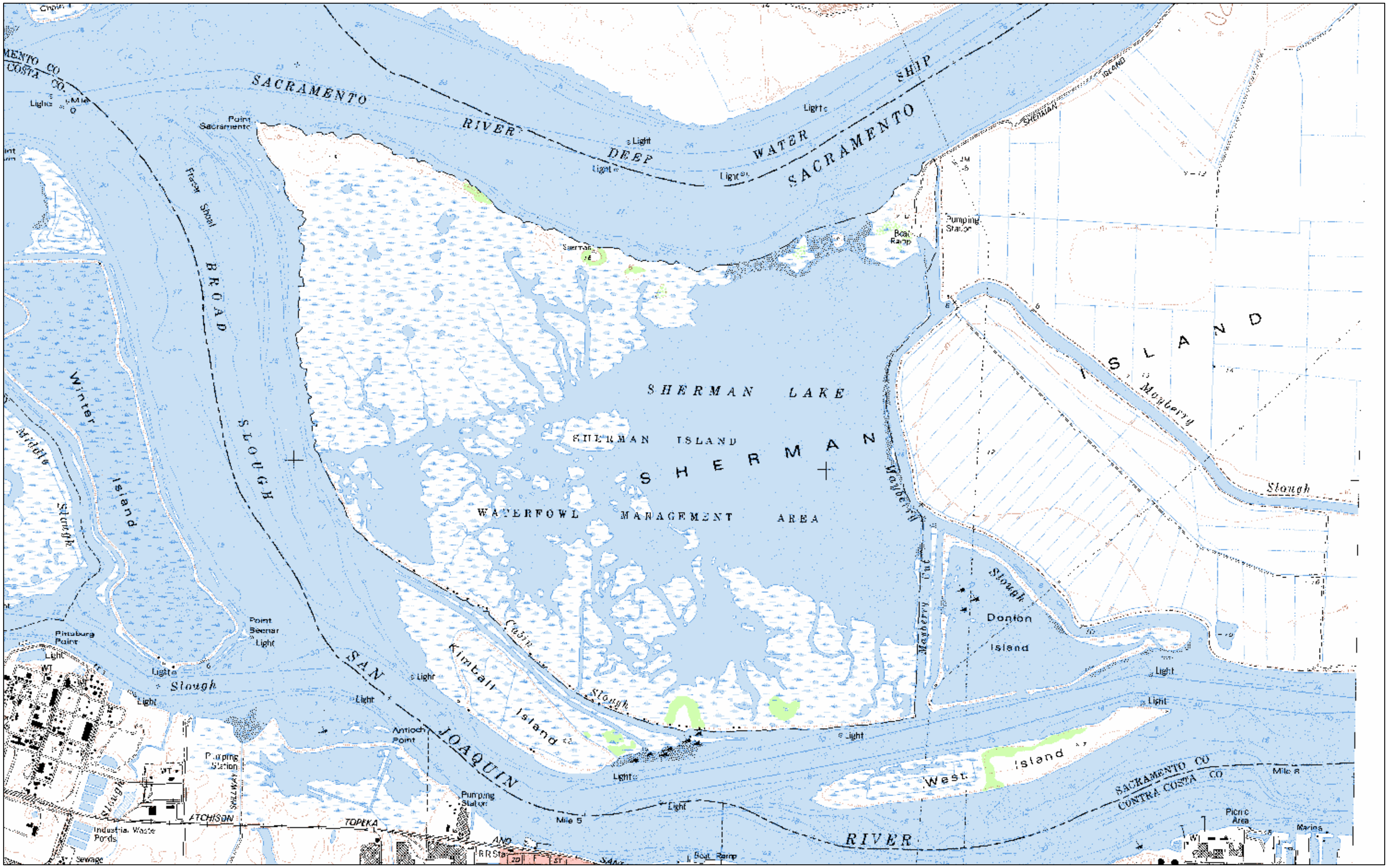

Source: Antioch North Quad 1978

Lower Sherman Lake

EXHIBIT 1-4

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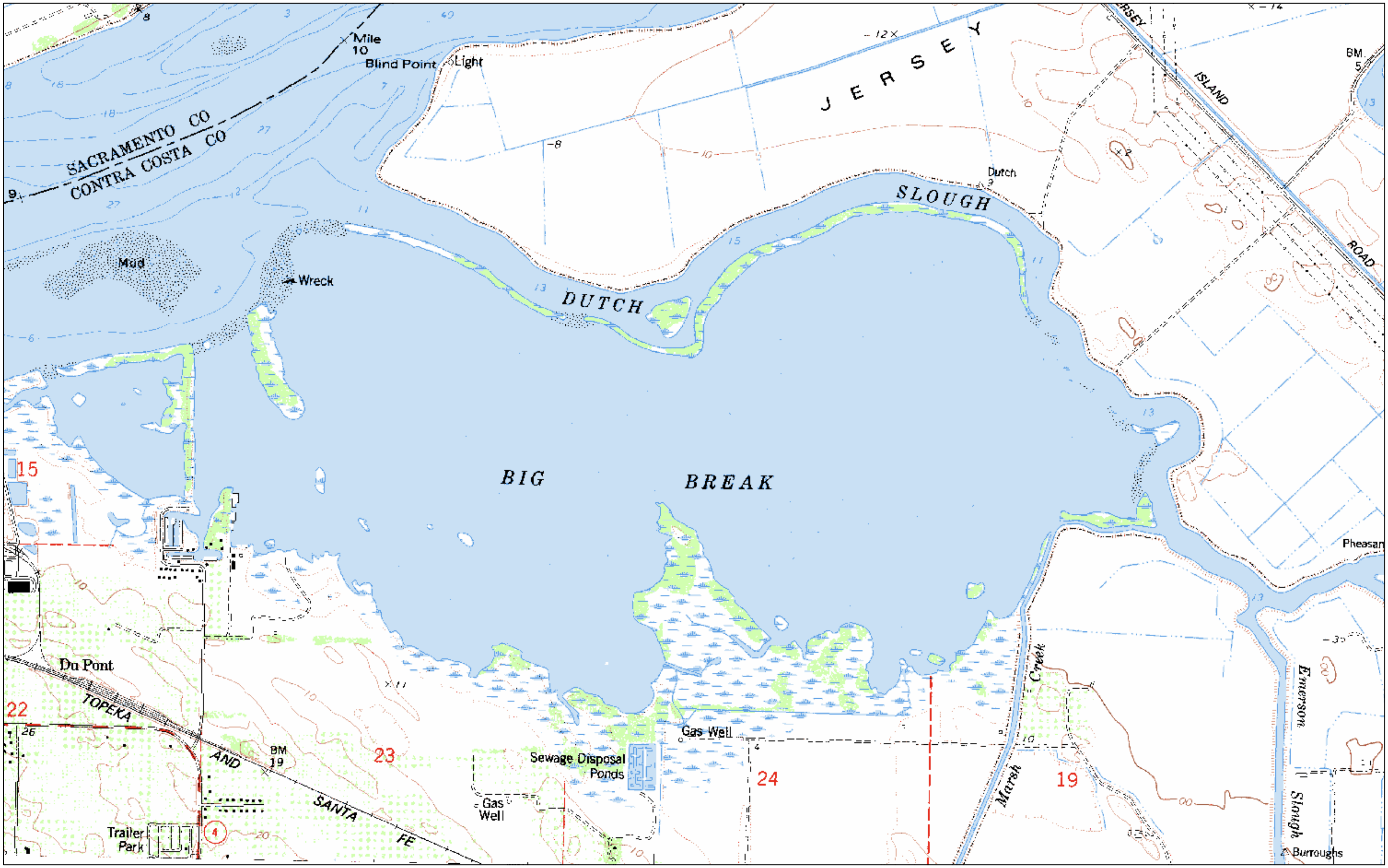

Source: USGS Jersey Island Quad 1978

Big Break

EXHIBIT 1-5

Flooded Islands Pre-Feasibility Study Report

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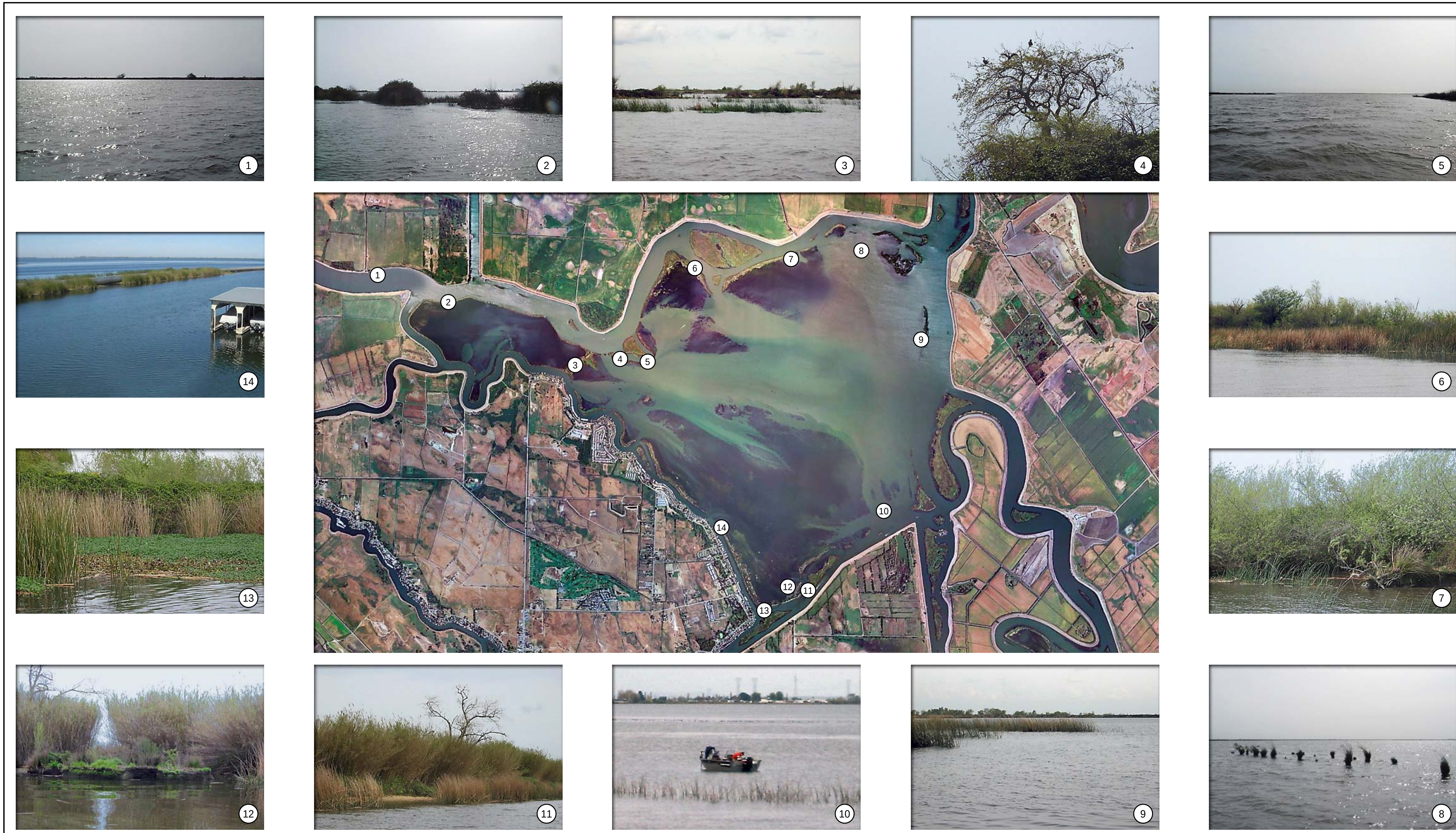
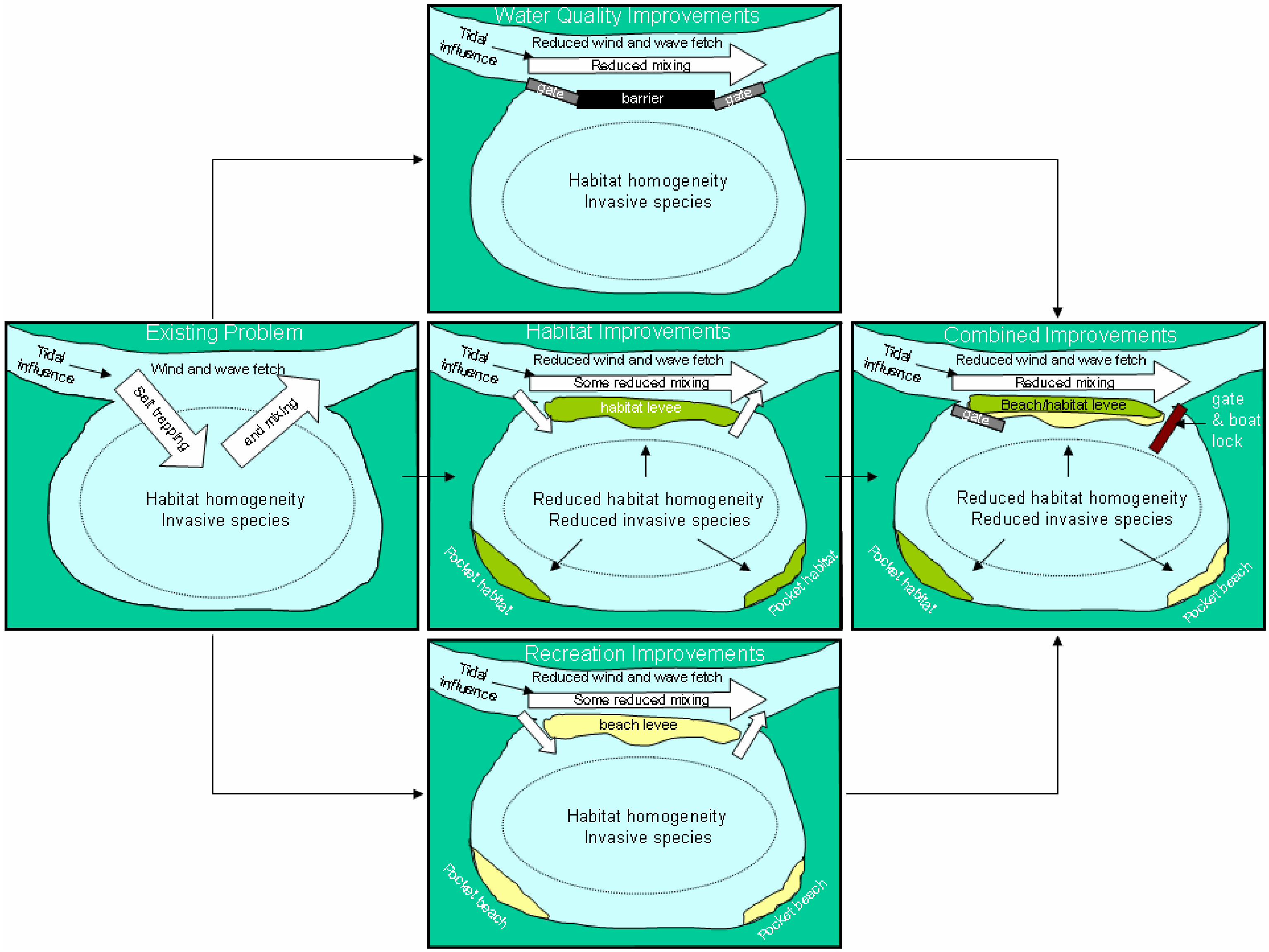


Source: EDAW 2005, Air Photo U.S.A. 2002

Existing Conditions at Franks Tract

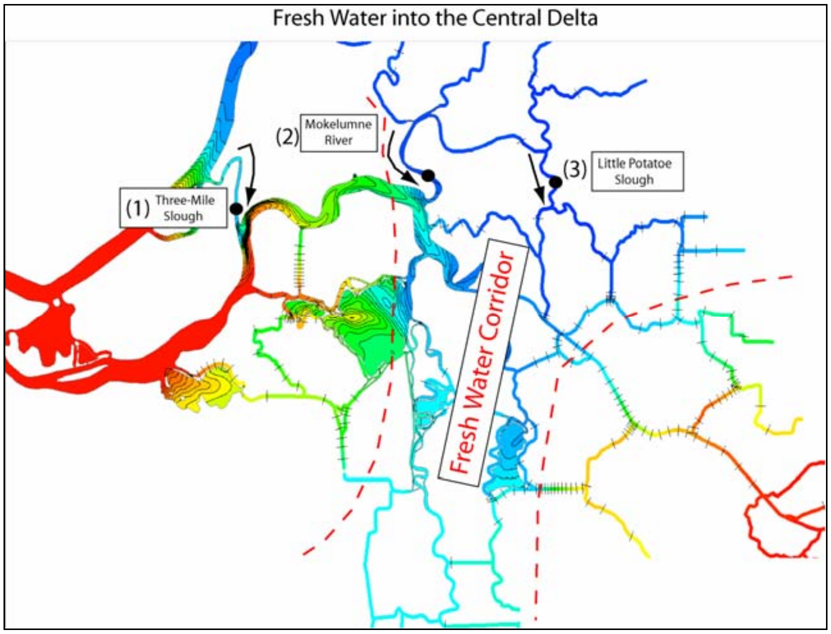
EXHIBIT 1-6



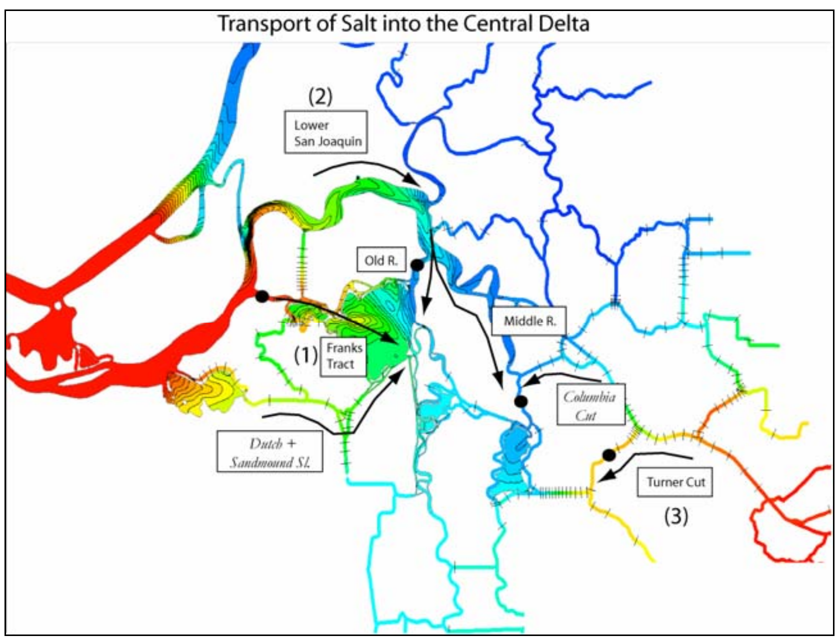
Source: Natural Heritage Institute 2005, DWR 2001

Conceptual Model of the Flooded Islands Pre-Feasibility Study

EXHIBIT 1-7



Salt concentration from a numerical simulation is shown in terms of color – cooler colors (blue) represent relatively fresh water, warmer colors (red) saltier water. Fresh water is exchanged into the central Delta through three paths (1) Threemile Slough, (2) the Mokelumne River, (3) Little Potato Slough. Fresh water from these channels is mixed with saltier water from the west and south creating a "fresh water corridor" represented by the north-to-south blue to cyan band.



Salt concentration from a numerical simulation is shown in terms of color – cooler colors (blue) represent relatively fresh water, warmer colors (red) represent saltier water. Salty water is exchanged into the central Delta through three main pathways: (1) through False River into Franks Tract, (2) through the lower San Joaquin River, and (3) Turner Cut. Secondary pathways through (a) Dutch and Sandmound Slough, (b) Old River and Middle River and (c) Columbia Cut also convey salt into the central Delta.

Source: J. Burau (USGS) and J. DeGeorge (RMA), unpublished

Delta Salinity Transport Processes

EXHIBIT 1-8

EDAW

2 OPPORTUNITIES AND CONSTRAINTS ANALYSIS

2.1 OVERVIEW

This chapter presents the opportunities and constraints for the Pre-Feasibility Study. The development of alternatives is an essential step in the restoration of the flooded islands. Detailed analysis of opportunities and constraints provides a logical method to identify, evaluate, and compare/contrast alternatives, facilitate consideration of a range of reasonable alternatives, and provide the basis for the selection of a preferred alternative(s). Alternatives development and analysis, as described below, builds on the study's objectives and, in conjunction with the opportunities and constraints analysis herein, will shape the formulation of a series of alternatives and selection of a preferred alternative(s) and pilot program.

This chapter presents the main issues and provides an analysis of the opportunities and constraints in achieving the primary Pre-Feasibility Study objectives. Its purpose is to compile available information to inform the alternatives development, analysis, and selection process. An opportunity is defined as an identifiable benefit that can be achieved through implementation that contributes to the study's overall goals and objectives of creating water quality, ecosystem, recreation, and other benefits at the study area. Opportunities may also include possibilities for experiments and research to better understand some of the more complex and less understood conditions/issues surrounding the Delta environment. A constraint is defined as a factor that may limit the alternatives selection, or that may limit the extent to which the study's objectives are met. These initial opportunities and constraints influence the ability to achieve target objectives and drive design parameters; constraints, in particular, can prevent desirable restoration and/or improvement elements from being incorporated. In some cases objectives can be competing, and a single condition/issue can be both an opportunity and constraint. Because of the complex nature of the Delta environment and ecosystem, several important uncertainties were identified. These uncertainties were generally treated as constraints; however, in some cases, uncertainties were also identified as opportunities for research to gain a better understanding of issues that could potentially be applied to other projects/regions throughout the Delta.

Potential approaches to achieve the study objectives were developed from the initial analysis. The potential approaches are intended to take advantage of opportunities and address constraints. Development of the potential approaches was based on expert opinion, stakeholder input, and generally accepted and/or proven methodologies and techniques. Because of the preliminary nature of the study, potential approaches are specifically intended to be conceptual and general with the assumption that additional details shall be developed in subsequent phases. Potential approaches for addressing uncertainties may include experimental design, adaptive management, monitoring and research, and operational flexibility.

This chapter assimilates existing and new information from the following sources: interviews with stakeholders and scientific experts; Technical Memorandum #1: Public Outreach, Science

Advisory Group, and Integration Team Process; Flooded Islands Feasibility Study, Baseline Report; Technical Memorandum #2: Problem and Objectives Statement; Model Calibration Report; Conceptual Alternatives Report; and the opportunities and constraints revealed through earlier and ongoing Feasibility Study work. A more detailed discussion of the specific conditions and issues that may be affected by modifications to the flooded islands can be found in the Feasibility Study Baseline Report. This chapter presents the initial opportunities and constraints posed by the following conditions/issues affecting the study:

< Water Quality
  - Salinity
  - Organic Carbon
  - Mercury (Methylation)

< Ecosystem
  - Tidal Marsh
  - Riparian Scrub
  - Fisheries
  - Invasive and other Nonnative Species

< Recreation
  - Boating Access and Navigation
  - Open Water
  - Facilities

< Hydrodynamic Change and Associated Effects
  - Levees and Flood Protection
  - Agricultural Diverters

During the alternatives development process, a range of considerations, such as constructability, sustainability, function, cost, and regulatory permitting of specific elements, were also included. The initial opportunities and constraints outlined in this chapter are not comprehensive but are focused on issues important to decision-making during the planning process. A summary of goals and objectives, primary issues, opportunities, constraints, and potential approaches are provided in Table 2-1.

2.2 WATER QUALITY ISSUES

The following analysis discusses the opportunities, constraints, uncertainties, and potential approaches for achieving the water quality goals and objectives of the Feasibility Study. For this study, salinity is the key element of water quality addressed by the alternatives. Organic carbon and mercury issues are also evaluated. A primary objective of the Feasibility Study is to develop scenarios that would result in water quality improvements in the central and southern Delta for export and in-Delta uses. Potential water quality improvements would provide the most benefit in late summer and fall when Delta inflows are low and water demands are high, particularly during drought years. Consequently, the opportunities and constraints identified below are primarily associated with that general period when the alternatives would likely be used to the greatest extent. However, there may be the potential to use the alternatives for water quality and ecosystem improvements at other times of the year as well, and these issues are identified below where applicable.

The water quality opportunities and constraints in the Delta should also be categorized on a site-specific basis to the extent possible. Additionally, there are general functional or institutional opportunities and constraints that would be relevant to any major change in Delta features, placement, or function. This section identifies likely opportunities and constraints with respect to the location and the institutional/functional basis.

2.2.1 SALINITY

Water quality at all three study areas is influenced by their location within the salinity gradient in the Delta; salinity levels in the surrounding Delta channels range from freshwater to brackish. The location, geometry, and presence of specific breach and levee locations on Franks Tract in particular, result in saline water being trapped and mixed within the interior of the island. The saline water is then subject to hydrodynamic forces that result in salt transport further into the southern Delta where it may contribute to source water degradation for Delta water users. A map of Delta D-1641 water quality standard station locations is presented in Exhibit 2.2-1. A map of agricultural diversion locations is presented in Exhibit 2.2-2.

OPPORTUNITIES

- *Reduce salinities at the central and south Delta diversions and export facilities.* A primary opportunity is the ability to reduce central and southern Delta salinity, particularly as measured by concentrations of electrical conductivity (EC), total dissolved solids (TDS), chloride, and bromide. Modifications to flooded islands and adjacent channel geometry have the potential to alter Bay-derived salinity intrusion through the western Delta, including tidal prism (i.e., overall volume and areal extent of seawater intrusion), tidal excursion (i.e., distance of seawater intrusion), tidal pumping of high salinity water, salinity trapping in flooded islands, as well as other nonsalinity water quality characteristics and processes. Salinity reductions would thus improve the flexibility of State Water Project (SWP), Central Valley Project (CVP), and Contra Costa Water District (CCWD) operations to meet water quality objectives of the 1995 Delta Water Quality Control Plan (WQCP) for water delivered for municipal, industrial, and agricultural beneficial uses. The ability of water purveyors to meet secondary drinking water quality standards in treated municipal water would also improve.

- *Achieve municipal benefits associated with salinity reductions at central and south Delta diversions and export facilities.* Salinity improvements at the major southern Delta municipal source water supply diversion points (i.e., SWP, CVP, and CCWD), would improve the suitability and reduce public health risk of treated municipal water supplies for millions of California residents. In particular, reducing the proportion of seawater that reaches the southern Delta would incrementally reduce bromide concentrations that are associated with this water source. This in turn would reduce bromate formation during water treatment disinfection. The size and cost of future water treatment infrastructure could also be incrementally reduced. Improved water quality in source water diverted and/or exported from the Delta could improve the use and flexibility of groundwater recharge operations and conjunctive use programs. Decreased salinity in Delta source water used for municipal supply may extend or preserve local water supplies with better water quality that might otherwise be used to blend with the Delta source water. Decreased salinity concentrations in source water would also result in improved quality of recycled water and thus benefiting recycled water programs.

< *Achieve agricultural benefits associated with salinity reductions in the central and south Delta and at diversions and export facilities.* Reduced central and southern Delta salinity would improve water quality for agricultural water users in the Delta and the San Joaquin Valley. Reduced salinity in Delta water delivered or pumped for agricultural uses would likely result in a subsequent reduction in salinity concentrations and salt mass loading of irrigation return flows in the Delta and via the San Joaquin River. Reduced salinity may reduce the amount of water used to pre-irrigate fields for the purpose of salt leaching.

< *Increase the efficiency, flexibility, reliability, and assurance of upstream SWP/CVP reservoir operations to meet multiple use objectives and standards.* Under status quo conditions of Delta inflow, Delta outflow, and Delta water diversions, there is a general institutional opportunity to increase the efficiency, flexibility, reliability, and assurance of upstream SWP/CVP reservoir operations to meet multiple Delta water use objectives and WQCP standards, via four issues:

- Reduced salinity in the central and southern Delta would improve compliance with Delta water quality standards and thus reduce the quantity of water released (i.e., carriage water), or at a minimum increase the flexibility of current reservoir release and pumping patterns.

- Depending on the specific configuration of selected improvements, efficiency of cross-Delta freshwater flow from the Delta Cross Channel (DCC) could improve.

- Depending on the specific geometry of selected improvements, efficiency of water released to satisfy carriage water provisions (e.g., Delta water quality standards, ecological standards, X2,[1] and minimum Delta outflow) could improve.

- Efficiency in meeting target delivery and water quality objectives could preserve and extend freshwater reservoir water supplies and thereby improve drought year protection, or maintain a similar level of protection.

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[1] "X2" is a regulatory tool that represents the location in the Delta measured from the Golden Gate Bridge (in kilometers), in bottom salinity concentration of 2 parts per thousand (equivalent to an EC of 2,640 microSiemens per centimeter). X2 is the approximate location of the entrapment zone, an area of high biological productivity.

< *Increase the efficiency of Delta outflows to control X2*. Potential modifications could result in a decrease in tidal prism that could contribute to the efficiency of Delta outflow adjustments (i.e., carriage water) made to specifically control X2 position west of the study areas and thus benefit ecosystem functions of the entrapment zone.

< *Potential for synergistic benefits associated with other Delta operations*. Potential improvements, when combined with the effects of other major Delta structural and operational changes (e.g., South Delta Improvements, North Delta, *DCC*, Reclamation studies) could potentially improve the overall ability of water project operators to increase water deliveries and to meet water quality requirements.

CONSTRAINTS

Potential salinity constraints may include:

< *Potential for adverse changes in residence time and reverse flows in the San Joaquin River*. The available methods of manipulating Delta geometry south of the lower San Joaquin River to repel seawater intrusion inherently results in two potentially adverse conditions, depending on water year type, background water quality, and seasonal timing:

- Depending on the geometry or selected features, daily tidal exchange could be muted or otherwise constrained, such that hydraulic residence time at specific locations could increase. Although tidal excursion, trapping, and pumping of peak salinity levels may be reduced, increased residence time could result in longer duration of slightly higher salinity compared to existing conditions.

- Depending on operations, alteration of the dominant flow path for water drawn to the SWP and CVP pumps in the south Delta could exacerbate reverse flows in the San Joaquin River.

< *Potential adverse changes (increases) in salinity concentrations at other Delta locations*. Depending on the specific geometry of selected improvements, some Delta locations could experience higher overall salinity levels via shifting of hydrodynamic transport mechanisms and salt transport. The magnitude and spatial extent of potential salinity increases compared to the area and magnitude of potential salinity reductions needs to be considered in light of the specific resources that would be affected in those areas. Key potential concerns about the likely alternatives include:

- salinity increases at agricultural water supply intakes;

- hydrodynamic effects that may alter the proportion of water supplies derived from the interior and western Delta, North Delta, and San Joaquin Valley;

- hydrodynamic effects of reduced tidal prism on water levels of south Delta agricultural water users; and

- indirect water quality effects if relocation of agricultural intakes or drains is required.

< *Potential for changes in flow–salinity relationships that could affect SWP/CVP operations and Delta water quality standards.* A potential institutional constraint is that salinity changes could alter the long-standing flow–salinity and reverse flow relationships that SWP/CVP operations evaluate and rely on to comply with Delta water quality standards. The ramifications of the potential salinity shifts are difficult to determine at this stage in the study planning because the potential management responses to changing salinity conditions may be subject to considerable scrutiny and regulatory controls. Examples of potential responses of primary importance include:

- SWP/CVP reservoir and Delta export operational responses to improved salinity may be objectionable if Delta water use increases in response to improved water quality and there are unknown direct or indirect water quality or ecosystem effects of those responses.

- Modeling of water supply operational or regulatory responses to salinity shifts at existing standard locations may take considerable negotiation to develop "operating rules."

- Existing Delta management and regulatory controls have taken years to develop and negotiate; there may be general reluctance to manipulations of physical Delta geometry and hydrodynamic functions until there are assurances of effectiveness, safeguards, and management plans that address multi-stakeholder concerns.

< *Potential adverse changes (increase) in salinity concentrations at other south Delta locations.* Although overall water quality in the southern Delta could improve, there may be hydrodynamic effects that result in exposure of some water users to a greater percentage of lesser quality water that enters the Delta from the San Joaquin Valley.

< *Potential for additional modeling coordination required to develop appropriate CVP/SWP operating assumptions.* Additional modeling of alternatives may be required for further planning. It may be deemed necessary to use the RMA model in an interactive mode with CALSIM2 input scenarios to model potential long-term effects on SWP/CVP water supply operations or other resource issues (WQCP and D-1641 compliance) or other planned programs (e.g., South Delta Improvements). Coordination of the two models could be necessary to develop appropriate operating assumptions.

POTENTIAL APPROACHES

< *Levee reconstruction and/or new levee construction.* Opportunities exist to reconstruct existing levees and/or construct new levees to change geometry and hydrodynamics, resulting in salinity reductions at south Delta diversions and export facilities.

- *Incorporate the use of operable gates and locate facilities to optimize benefits and allow for increased water quality management (including adaptive)*. Operable gates and potential facility locations would likely provide the most flexibility to manage and optimize water quality and ecosystem tradeoffs of features that effect tidal prism, residence time, salt trapping, tidal pumping, and ebb tide flushing to transport salinity into the western Delta.

- *Consider safety and flexibility factors into potential element designs*. Designs should consider factors of robustness, redundancy, and flexibility in light of potential unforeseen upset (e.g., seismic failure, accidental structural damage or mechanical failure, levee breaks, flood overtopping or damage, sediment scour or deposition).

2.2.2 ORGANIC CARBON

Delta inflows, island drainage discharges, miscellaneous waste discharges, and in-channel processes all contribute to organic carbon cycling and associated ecosystem effects and contaminant potential of Delta source waters used for drinking water. The relative importance of each at any given time depends on many variables, including location, sources and loads, channel flows, tides, and biological processes. River sources of organic carbon appear to dominate in the winter whereas biological processes (e.g., wetland export and phytoplankton growth) in the Delta appear to dominate in the spring and summer (CALFED 1999). Dissolved organic carbon (DOC) is defined as that which can pass through a 0.45-μm filter; particulate organic carbon (POC) is retained by the filter. The combination of DOC and POC are referred to as total organic carbon (TOC). DOC varies considerably in quality and consists of a complex heterogeneous mixture of organic molecules with different molecular weights, solubilities, polarities, reactivities, and bioavailability. DOC quality varies considerably among sources and in Delta channels is not a simple mixture of DOC from the rivers and DOC in the agricultural drains. The quality of the DOC is as important as the quantity in affecting beneficial productivity in the food web and adverse trihalomethane (THM) formation potential in drinking water exports. Phytoplankton production is the dominant source of organic matter for the Delta's pelagic food web (Sobczak et al. 2005). Phytoplankton are also believed to be a source form, although, to a lesser extent than other sources forms (e.g., wetland export and agricultural [peat island] drainage), of reactive DOC potentially leading to THM formation (DWR 1994; Jassby and Cloern 2000; Brown 2003a). A more detailed discussion of organic carbon sources, forms, processes and ecological and water quality implications can be found in Section 4.4 of the Flooded Islands Feasibility Study Baseline Report. A conceptual model of organic carbon processes in the Delta is presented in Exhibit 2.2-3. A map of agricultural drainage returns is presented in Exhibit 2.2-4.

OPPORTUNITIES

- *Reduce DOC concentrations to central and south Delta diversion and export facilities*. Related to the salinity improvements, increased efficiency of Delta cross-flow of Sacramento River water into the southern Delta could reduce DOC in SWP and CVP pumps and CCWD diversions and thus incrementally reduce health risks from THM formation in treated water supplies. Similar to salinity, the water quality improvement could increase the ability for water purveyors to comply with water quality standards, and incrementally reduce the size and cost of future water treatment infrastructure and ongoing associated operations costs of water treatment.

< *Potential to increase primary (phytoplankton) productivity in the Delta.* Light penetration, hydraulic residence in Delta channels and Franks Tract, quiescent water conditions, abundant nutrient supply in the Delta (e.g., nitrogen and phosphorus), sunny Mediterranean climate, and warm temperatures are all key factors that contribute to Delta phytoplankton production(Jassby et al. 2002). While light penetration has been determined to be a primary limiting factor to phytoplankton growth (Jassby et al. 2002), the potential exists for manipulation of hydrodynamics, channel configuration, and ecosystem functions within the study area to improve in-Delta phytoplankton production. Phytoplankton biomass production is necessary to support a Delta food web of diverse and desirable species, particularly when the algae consist of varieties favored by consumer organisms.

< *Potential for decreases in DOC to central and south Delta diversion and export facilities*. Potential improvements in the efficiency of cross-Delta flows from the Sacramento River into the southern Delta have the potential to reduce DOC transport to SWP, CVP, and CCWD water intake locations from in-Delta agricultural drainage, wetland export, and phytoplankton production.

< *Increased understanding of planktonic, food web, and organic carbon related processes.* Manipulations of the flooded islands offer great opportunities to study and research planktonic, food web, and organic carbon related processes in the flooded islands.

CONSTRAINTS

< *Uncertainties in invasive species DOC production.* The direct role in DOC production and potential THM formation by the extensive Egeria beds, other vascular macrophytes, and epiphytes within Franks Tract, Little Franks Tract, and other regions of the study area is uncertain. The extremely large distribution of existing populations presents considerable potential contribution of DOC, especially on a seasonal basis (e.g., winter senescence).

< *Uncertainties in ecosystem response and subsequent carbon processes resulting from site modifications.* The ecosystem response of potential strategies in terms of DOC production, concentrations, loading, and fate and transport is highly uncertain. This uncertainty may result in less accurate assessment and development of potential strategies that best optimize water quality improvement opportunities and constraints. However, some general known factors and assumptions are useful for potential strategy planning as follows.

- Potential for increases in DOC to central and south Delta diversion and export facilities. The potential for direct or indirect increases of net in-Delta DOC production and/or transport of DOC from Delta tributaries (i.e., Sacramento and San Joaquin Rivers, eastside streams) or in-Delta sources (e.g., wastewater treatment, agricultural drainage, wetland export) to the affected M & I intake locations would be a potential major constraint for water quality regulatory compliance.

- Potential adverse changes in residence times resulting from site modifications. Increased in-Delta primary production from residence-time effects, or increased transport of phytoplankton-related DOC (and possibly vascular aquatic macrophytes) into the southern Delta could adversely increase the public health risks from THMs because the DOC associated with living plants is believed to possess higher reactivity and THM-formation potential in water treatment processes. Phytoplankton production and seasonal timing are factors that cannot be predicted through hydrodynamic modeling of water mass and transport alone. For example, the strong east-trending wind fetch in the Delta could result in buoyant organisms accumulating on the lee side of water features and thus be differentially subject to water movements in Delta channels. The nearly continuous reverse flow conditions within Old and Middle Rivers in late summer and fall resulting from the pumping of the SWP and CVP facilities could have the potential to draw accumulated phytoplankton southward during ebb tide operations.

  In addition, it is possible that increased residence time, if long enough, could result in the draw-down of nutrients by phytoplankton and shifts in nutrient ratios, resulting in changes in the phytoplankton community. A decrease in the nitrogen-to-phosphorus ratio could, for example, favor cyanobacteria production, which are not generally a high quality food source for the pelagic food web and which can be toxic. Mere changes in mixing intensity could also result in species shifts.

- Potential strategies that alter or limit water velocities could result in expanded areas of Egeria infestation. The Egeria beds are capable of supporting a substantial variety of other epiphytic plants, algae, and bacteria; however, the role that these assemblages play in DOC production, breakdown, and other fate and transport functions is not clear.

- Uncertainties in invasive species incidental grazing. The direct role of invasive clams within Franks Tract, Little Franks Tract, and other regions of the study area is uncertain. The filter feeding rate of clams (*Potamocorbula* and *Corbicula*) results in rapid cycling of water and is believed to play a dominant role in the food chain, primarily by the high rate of algae consumption and associated disruption of this key element of Delta primary production (Lucas et al. 2002). While the clams have been a stable presence in the Delta since the late 1980s and apparently are resilient over a wide range of habitat, substrate, salinity, hydrodynamic, predatorial, and water year-type conditions, it is not understood why Corbicula densely populate some parts of the Delta and are absent in others. Given the potential changes (e.g., flows, mixing, temperature food resources, chemistry, biota, and/or turbidity) resulting from manipulations to the study areas, it is uncertain as to whether current Corbicula populations would sustain themselves in their current locations and at their current levels, thus making predictions of future grazing rates uncertain.

- *Improvement elements could result in compaction of organic sediments and ejection of enriched pore waters into overlying water.* Study features and elements could result in compaction of organic sediments and ejection of pore waters containing concentrations of DOC into overlying water. The ejection of pore water could result in increased DOC resulting in unknown ecosystem response and THM formation potential at export/diversion facilities.

POTENTIAL APPROACHES

< *Perform baseline testing and post-implementation monitoring to better understand planktonic, food web, and organic carbon related processes*. To understand the effects of implementation and adaptive management of such a change to the environment, coordinated multidisciplinary ongoing measurements of the physics, chemistry and biota would be needed both before and after project implementation. It may be necessary for the post-implementation monitoring to take place over several seasons and perhaps even over several years, since ecological responses in the region may require years to take hold, and those responses could be regulated by annually varying climatic, hydrologic, and operational conditions (also see Chapter 5).

< *Incorporate the use of operable gates to allow experimental adaptive management of flows and residence times.* Operable gates and other elements that maximize the ability to flush DOC into the western Delta would provide the greatest level of flexibility for avoiding adverse effects.

< *Consider potential increases in DOC production resulting from ecosystem restoration elements.* How wetlands function affect DOC production and timing, and how hydrodynamic processes transport DOC from wetlands is not well understood (Brown 2003a). The uncertainty of these effects needs to be considered in the planning and design of proposed wetland features to optimize the ability to control, manage, or otherwise assure that adverse DOC effects to M & I purveyors would not occur.

< *Consider clam grazing effects in planning and implementation.* Potential strategies should be developed with the understanding that Corbicula and/or *Potamocorbula* populations and distribution could be altered, and thus the existing strong algae consuming effect that they exert in the interior and western Delta could change.

2.2.3 MERCURY

Mercury (Hg) results from natural and anthropogenic sources in the environment and continually cycles in the aquatic environments of the Sacramento and San Joaquin River basins and Delta. In-Delta methyl mercury (MeHg) formation processes may be as important a factor to ecosystem exposure and uptake in the food chain as the much larger overall riverine inputs of mineralized forms. Total Hg concentrations in coastal mountain streams can be two orders of magnitude higher than concentrations in Sierra mountain streams where the MeHg concentration patterns were equivalent (Jones and Slotten 1996).

Methylation of Hg is the key step in the entrance of Hg into the food web. Nearly 100% of the Hg that bioaccumulates in fish tissue is methylated. The rates of methylation in the Delta are influenced by the bioavailability of inorganic Hg to methylating bacteria, the concentration and form of inorganic Hg, and the distribution and activity of methylating (i.e., sulfate-reducing) bacteria (Jones and Slotten 1996; Heim et al. 2003). Solid phase MeHg concentrations vary seasonally; the highest concentrations occur during late spring and summer (Heim et al. 2003). Gill et al. (2002) found that sediments appear to be a net source of methyl mercury to the water column. Stephenson et al. (2002), who employed a mass balance approach, suggests that the Delta is a sink for methyl mercury, due to photodemethylation or storage via bioaccumulation. Slotton et al. (2003) suggests that inorganic mercury newly delivered from upstream sources is more readily methylated and bioaccumulated than inorganic mercury stored in the Delta.

Dense wetlands may export MeHg to surrounding channels (Heim et al. 2003); however, biological findings indicate no distinct localized increase in net MeHg bioaccumulation in flooded wetland tracts versus adjacent aquatic habitats within Delta subregions (Slotten et al. 2003). Some of the most well developed, highly vegetated wetland tracts have exhibited reduced levels of localized net mercury bioaccumulation (Slotten et al. 2003). Additionally, recent findings on MeHg production rates suggest that there may be an inverse relationship between environmental conditions that support high concentrations of bioavailable mercury (e.g., relatively clean inorganic sediments) and those that support high sulfate reduction rates (e.g., oxic-anoxic sediment interface with relatively high amounts of organic material) (Marvin-DiPasquale, pers. comm., 2005). These results suggest that wetland restoration may result in localized mercury bioaccumulation at levels similar to, but not necessarily greater than, levels within their surrounding Delta subregion. A more detailed discussion of mercury sources, forms, and processes can be found in Section 4.4 of the Flooded Islands Feasibility Study Baseline Report. A conceptual model of mercury processes in the Delta is presented in Exhibit 2.2-5.

OPPORTUNITIES

< *Improved understanding of Delta mercury contamination and processes is progressing, and relative risks of potential strategies can be better qualified.* The historical and existing mercury bioaccumulation and biomagnification in the Delta food web is an important ecological and human health issue for consideration in the planning and development of the proposed alternative(s). The scientific understanding of factors controlling the formation of MeHg, fate and transport and biotic uptake in Delta environments is progressing, and extensive research continues. Although there could be considerable uncertainty in the quantification of MeHg effects caused by changes in hydrodynamic, water quality, and other ecosystem factors that may be affected by the proposed study, the relative risks of MeHg production

under various geometry and operational scenarios can be qualitatively assessed based on known principles.

< *Diversity of MeHg processes provides assurance of minimal ecosystem changes compared to existing conditions.* Several fundamental and well-understood factors of MeHg interactions suggest that large-scale hydrodynamic functions may not have a substantial effect on MeHg, compared to existing conditions. Mercury research from the Delta and tributaries consistently indicates that sediment MeHg concentrations, MeHg formation and demethylation, organism uptake and bioaccumulation, and mass flux of MeHg transfer from sediment to water are highly dynamic processes that can vary considerably, depending on the habitat (e.g., wetlands/marsh, farmed wetlands, open water, Egeria beds), location in the Delta, and a host of other factors (e.g., hydrologic factors, salinity, pH, temperature, organic matter, temporal-seasonal conditions) (Jones and Slotten 1996, Foe 2002, Gill et al. 2002, Stephenson et al. 2002, Choe and Gill 2003, Choe et al. 2003, Davis et al. 2003, Foe et al. 2003, Heim et al. 2003, Slotten et al. 2003, Wiener et al. 2003). It is precisely this wide diversity of processes, all of which contribute to MeHg interactions, that provides some level of assurance that changes in hydrodynamic and ecosystem functions may not substantially alter the existing dynamism and overall level of MeHg interactions within the study area. Moreover, the proposed strategies may be implemented primarily on an interim seasonal and daily temporary basis to manipulate salinity, and thus represent only an incremental and nonpermanent shift in the existing conditions.

< *Study elements could reduce known MeHg production factors.* Despite the diversity and dynamism of MeHg interactions, there are several identified and potential study-related changes in hydrodynamics and habitat improvements that could be implemented to generally reduce the influence of known MeHg factors. Key potential opportunities include:

  - Constructed habitats with imported low-mercury content fill sediments could reduce the exposure of existing sediments that were exposed to historic mining mercury inputs. Replacement, reconstruction, and new levee construction activities with clean fill could cover and/or reduce existing extensive areas of potential MeHg formation sites and aquatic organism exposure. When coupled with habitat objectives and substantial species population enhancement improvements, the food web could be enhanced by low organism exposure to MeHg.

  - Reducing exposure of habitat sediments to seawater-based sulfate concentrations decreases sulfate reduction rates for bacteria within brackish estuarine environments (Davis et al. 2003). Salinity in the study area fluctuates within the range that is conducive to sulfate reducing bacteria activity. Strategies that reduce tidal prism in the interior Delta could reduce the tidal excursion and the frequency to which sediments are exposed to elevated sulfate levels.

< *Opportunities for increased understanding of MeHg production processes through the development of controlled large-scale adaptive management strategies.* Because mercury research is evolving, a large-scale study that exerts substantial control over hydrodynamic forces in the Delta

represents a key opportunity for conducting definitive MeHg fate and transport research and developing adaptive management controls. Current mercury research is focused on developing the understanding of factors involved with the ultimate fate and transport of MeHg within the Delta and biotic uptake processes. Although the Delta is a highly manipulated environment compared to historical conditions in terms of such issues as land use, tidal hydrodynamics, and freshwater inflow patterns, the study area in particular and the suite of likely study strategies for regulating tidal prism and hydrodynamics is a unique opportunity. A comprehensive monitoring strategy for the proposed study could contribute substantially to the understanding and advancement of MeHg processes and environmental responses as follows:

- *Changes between pre- and post-study conditions.* Strategies that would isolate specific existing water or habitat features, remove or modify existing structures/habitats, provide new controls on existing hydrodynamic or water chemistry conditions, or otherwise modify a known potential MeHg contributing function could represent an ideal opportunity to compare pre- and post-study MeHg dynamics. Pre- and post-study comparisons are key methodologies used to identify and quantify the relative importance of contributing factors of ecosystem responses. The approach requires and depends on carefully crafted experimental plans and monitoring methods. An example element might be the monitoring of pre- and post-study MeHg formation rates in a specific area that is destined to be exposed to substantially lower frequency of sulfate exposure from salinity intrusion. Numerous considerations are involved in the development of monitoring plans to ensure that data will yield useful information. A key consideration is the elimination of other influences, such as other important flow and water quality conditions that may vary between the pre- and post-study data sets. Other key methods to monitor and confirm ecosystem responses include monitoring paired background locations not affected by the study to isolate the interannual influences, and long-term trend monitoring to confirm that observations reflect a range of variable conditions.

- *Size of reactive mercury pool as a key factor in mass transport.* Recent research on MeHg formation indicates that the reactive pool of mercury is a key variable for the appropriate interpretation and application of reported MeHg formation rate values that have been used to assess potential mass flux estimates from various upland, wetland, and open water areas of the Delta estuary (Marvin-DiPasquale, pers. comm., 2005). This key new concept relates the distinct inverse relationship between the mass of ionic mercury (i.e., HgII+) in the sediment substrate that is available to sulfate reducing bacteria and the strength of the redox conditions, particularly in high organic content environments. Under strong reducing conditions, the reactive pool of mercury may be relatively low when mercury is bound within reduced chemical complexes and minerals (e.g., organometallic sulfides). However, the reactive pool of mercury under oxidized, moderately reducing, or variable redox conditions, and/or low organic content mineral substrates, may be considerably more available. Consequently, this new research indicates that existing MeHg formation rate or mass flux estimates that have not accounted for the reactive pool as a scalar factor may not accurately reflect the differences among habitat types and other controlling variables. A key outcome is that relatively elevated MeHg formation rates that have been reported for strongly reducing conditions of Delta wetland systems compared to open water areas may not accurately represent the MeHg mass flux from these systems, as compared to open water or mixed habitat types. Another key outcome of this new paradigm is that alterations of organic matter or other important factors of MeHg formation may be much more important for the existing oxic environments, where the reactive mercury pool may be greater. Studies could advance the understanding and management of these phenomena.

CONSTRAINTS

- *Existing uncertainties of some MeHg formation factors present institutional challenges.* The research consensus regarding important factors described above reflects considerable assurance that proposed study strategies could be implemented with a low risk of causing substantial adverse MeHg effects relative to existing conditions. However, there could be fundamental institutional concerns among regulators and environmental interest groups about allowing large-scale hydrodynamic manipulations or exposure of organisms to potential additional contamination above baseline conditions. One key potential regulatory hurdle is the existing identification of all Delta channels as impaired by mercury by the Central Valley Regional Board for the U. S. Environmental Protection Agency's Clean Water Act (CWA) Section 303(d), "List of Water Quality Limited Segments." The proposed study, if ultimately considered to have a substantial role in altering MeHg dynamics, would likely need to have a participatory role in the Total Maximum Daily Load program developed pursuant to CWA.

- *Improvement elements could result in compaction of organic sediments and ejection of enriched pore waters into overlying water.* Study features and elements could result in compaction of organic sediments and ejection of pore waters containing concentrations of Hg into overlying water. The ejection of pore water could result in increased Hg availability for methylation and subsequent bioaccumulation.

- *Known MeHg formation factors.* Study activities/features, location attributes, and operations that are generally acknowledged to represent the potential for increased MeHg interactions are:

  - Increases in residence time that promotes less water circulation, temperature increases or thermal stratification, increased sulfate concentrations, or chemically reducing conditions.

  - Exposure of the reactive pool of mercury to study-related manipulations that substantially alter the likelihood of MeHg formation and mass flux from sediment to water. Examples of the potential constraint include increased organic inputs and associated stimulation of increased sulfate reduction in existing oxic environments. Study strategies that result in substantial growth and decay of phytoplankton could serve as a highly reactive input of organic carbon to the sediment redox cycle that drives MeHg formation in open water areas.

POTENTIAL APPROACHES

- *Integrate MeHg formation consideration into study planning*. Conduct comprehensive planning of study feature locations and operations with respect to known MeHg formation factors and likely habitat use to minimize the risk of increased exposure of organisms and uptake of MeHg into the food web.

- *Perform baseline testing of existing reactive mercury levels in study area sediments to characterize the range of representative conditions, and subsequently develop study strategies that minimize adverse changes to the high-risk areas*. An example consideration is to minimize hydrodynamic and water chemistry alterations that would cause highly variable environmental conditions in high-risk sediments. Because of the recognized importance of the concept of the reactive pool of mercury, a keen interest has developed in the dynamic forces that result in the release of tightly bound Hg in organic sediments and likewise the release of existing stable pools of highly reactive Hg.

- *Test and use clean fill material for study features*. Use clean imported fill for facility construction, and/or use pre-study sediment testing to identify the potential borrow sites with the lowest Hg concentrations. This will reduce the net exposure of contaminated sediments to adverse MeHg formation factors.

- *Prepare and implement a monitoring and adaptive management plan*. Develop a monitoring and adaptive management plan in conjunction with baseline and fill material testing to assess study effects on MeHg formation and production rates.

2.3 ECOSYSTEM ISSUES

The following analysis discusses the opportunities, constraints, uncertainties, and potential approaches to ecosystem restoration for the purposes of achieving the goals and objectives of the Pre-Feasibility Study. The potential for achievement of CALFED Bay-Delta Ecosystem Restoration Program (ERP) and Multispecies Conservation Strategy (MSCS) goals and objectives is also discussed.

2.3.1 TIDAL MARSH RESTORATION

Identification of potentially feasible, emergent tidal marsh habitat sites suitable for restoration or rehabilitation is a goal of this study. Tidal marsh restoration and resulting benefits to special-status species also helps achieve goals and objectives of the ERP and MSCS.

OPPORTUNITIES

- *Substantially increase lower and upper tidal emergent marsh habitat through restoration*. There is an opportunity for conversion of existing open water and nonnative submerged aquatic vegetation (SAV) habitat (e.g., *Egeria densa*) to lower tidal marsh habitat (–1 ft. NGVD[2] to +2 ft. NGVD), a native habitat dominated by California bulrush (*Scirpus californicus*), and upper tidal marsh habitat (+2 ft. NGVD to +4 ft. NGVD), a native habitat dominated by common tule (*Scirpus acutus*), bulrush (*S. robustus*), rushes (*Juncus* spp.), and sedges (*Carex* spp.). Mean higher high water (MHHW) is approximately 3.38' above mean lower low water (MLLW) (Simenstad et al 2000, Hart et al 2003). This defines the lower edge of emergent marsh. At natural reference sites in the Delta, average marsh plains were close to MHHW. Thus, marsh vegetation occurs from -0.98' below NGVD to 2.99' above NGVD. Tidal marsh habitats may also displace and help prevent establishment of Egeria and other nonnative SAV habitat, may provide a buffer for shoreline stabilization of remnant levees and in-channel islands, provide sediment stabilization, and may allow for sediment accumulation to increase or sustain appropriate elevations supporting additional tidal marsh habitat. These habitats could also provide opportunities for native fish and invertebrate species, restoration or recruitment of the special-status plant species Suisun Marsh aster (*Aster lenus*) and Delta tule pea (*Laythrus jepsonii* var. *jepsonii*), and may have the potential of sustaining native pondweed (*Potamogeton* spp.).

< *Increase intertidal mudflat habitat through restoration*. There may be an opportunity for conversion of existing open water or nonnative SAV habitat to largely unvegetated tidal mudflat habitat (at the high tide line or "splash zone"). Creation of mudflats would depend upon whether suitable material is available to create this habitat type. The material at Decker Island is primarily silty-sand and likely would be suitable. Tidal mudflat habitat (or equivalent unvegetated substrates at similar elevations, such as those provided by anchored rootwads) may provide opportunities for restoration or recruitment of special-status plant species, such as Mason's lilaeopsis (*Lilaeopsis masonii*) and Delta mudwort (*Limosella subulata*).

< *Increase habitat for native wildlife species*. The creation of additional tidal marsh habitat and tidal mudflat habitat would benefit native invertebrates, birds, and fish (see, Section 2.3.3 "Fisheries," below, for a detailed discussion on fisheries). An increase in these habitats could increase the growth of organisms at the base of the food chain, such as phytoplankton and Chironomidae larvae, which could improve conditions for species at higher trophic levels. An increase in these habitats could benefit several Neotropical migratory birds, such as western kingbird (*Tyrannus verticalis*), cliff swallow (*Petrochelidon pyrrhonata*), and Wilson's warbler (*Wilsonia pusilla*). Tidal mudflat would especially benefit native shorebirds and wading birds, such as great egret (*Ardea alba*), western sandpiper (*Calidris mauri*), and long-billed dowitcher (*Limnodromus scolopaceus*). Waterfowl could benefit from an increase of additional marsh and tidal channels around the open deep water in Franks Tract. Increases in these habitats could also provide habitat for the giant garter snake (*Thamnophis gigas*) and western pond turtle [Emys (=*Clemmys) marmorata*], both native special-status reptile species, and special-status

[2] NGVD refers to the National Geodetic Vertical Datum of 1929 (NGVD29), one of many vertical datums. NGVD was developed by observing the mean sea level height at various spots around North America for about 18 years. Once the data was collected it was used to create a standard vertical datum for North America.

avian species, such as least bittern (*Ixobrychus exilis*), California black rail *Laterallus jamaicensis coturniculus*, and tricolored blackbird (*Agelaius tricolor*). Potential improvement elements, such as tidal gates, could be constructed to provide suitable habitat for native special-status bat species, such as pallid bat (*Antrozous pallidus*), fringed myotis (*Myotis thysanodes*), and Townsend's big-eared bat (*Plecotus townsendii townsendii*) (Bat Conservation Intl 2004). Remnant levees, in-channel islands, and detached setback levees may provide especially important habitat for native wildlife species because they would be isolated from on-shore predators, such as red fox (*Vulpes vulpes*) and feral cats (*Felis catus*). For additional information regarding species that may occur at the flooded islands and their habitat requirements, see Section 4.7 of the Flooded Islands Feasibility Study Baseline Report (EDAW 2005).

CONSTRAINTS

< *The extent of existing landforms that could be restored to tidal marsh through planting alone is very limited*. Because of subsidence, most of the study areas are at subtidal elevations (below –1 ft. NGVD), too deep for planting tidal marsh vegetation. Although California bulrush is tolerant of continuous yearlong inundation, little or no establishment or survival occurs at depths much below –3 feet NGVD. The limited survival of bulrush below this level is apparently due to low levels of sunlight, resulting in inadequate photosynthesis. The constraint on restoring bulrush at depths below –1 foot NGVD to –3 feet NGVD is primarily due to the difficulty of planting bulrush in deeper water unless preestablishment is possible before gradual inundation.

< *Potential tidal marsh restoration areas are further limited by scour and shoreline erosion from high energy currents and waves*. Hydraulic forces such as wind waves, boat wakes, tidal flows, and fluvial currents create conditions where restoration is not feasible. These forces cause uprooting of plantings and erosion of suitable substrates for planting.

< *Limited accessibility of restoration areas*. Accessing suitable landforms for restoration is difficult. Most appropriate tidal marsh restoration areas in the flooded islands are only accessible by boat. This would increase costs of restoration.

< *Increases in mosquito production is a potential constraint*. The restoration of tidal marsh habitats could increase mosquito production in these areas. Mosquitoes and mosquito-borne diseases (e.g., West Nile virus) are a significant public health and public perception issue. Restoration should be designed to reduce suitable conditions for mosquito breeding (e.g., slopes created with a smooth grade to prevent ponding of water), and to favor the presence of natural biological controls (predators) to suppress mosquito populations (e.g., fish and bats).

< *Competing uses of proposed habitats could reduce their value for native wildlife*. Some uses that currently exist and could be increased at the flooded islands (e.g., recreational boating and fishing) could be competing uses with wildlife habitat creation, thus reducing the potential value of this habitat. For example, current levels of boating and fishing may reduce

waterfowl presence, and could reduce the use of restored tidal mudflats by shorebirds and wading birds.

< *Invasive species colonization*. Because much of the Delta contains nonnative invasive species, it is often difficult to control their introduction or spread. The creation or restoration of tidal marsh habitats would require design and management techniques to reduce colonization of nonnative plants, such as Egeria, and discourage use by nonnative fish species. (See Section 2.3.3, "Fisheries," for a detailed discussion on Egeria effects on fisheries.)

< *Uncertainties*. Uncertainties pose potential constraints and may include the following:

- The long-term sustainability of tidal marsh restoration is largely unknown because most projects that have been implemented are too recent to show long-term results.

- The benefits to fish and wildlife of tidal marsh restoration are not well documented because of the difficulties and expense of determining trends separate from fluctuations caused by other variables (e.g., season, weather, etc.).

POTENTIAL APPROACHES

< *Design tidal marsh at appropriate elevations.* Setback levees could be constructed using fill materials at elevations (–1 foot to +4 feet NGVD) suitable for tidal marsh restoration. Material excavated from Decker Island or dredge material from other sources including Franks Tract, could be used to fill areas adjacent to the setback levees and within Little Franks Tract to create tidal marsh. Precise elevations would be determined based upon expected settlement and the desire not to overfill. Restored areas in the Delta may be subject to further consolidation if loaded with fill material because of the low bearing capacity of the peat substrate (PWA 2002). However, overfilling can in inhibit channel formation (Williams and Orr 2002, Orr et al 2003). In order to determine precise optimum elevations for tidal marsh restoration, additional research would be required. It is likely that a range of elevations would be proposed and tested. In addition, fill material could also be placed in shallow subtidal waters adjacent to existing or constructed tidal marsh to maximize benefits for native fish species.

< *Experimental design of dendritic channels within tidal marsh.* At this time, the most likely source of material to be used to create tidal marsh for this project is from Decker Island. This material is primarily silty sand and in general, is suitable for creation of tidal marsh. A technique that could be utilized to create dendritic channels could be to pre-excavate channels prior to placement of fill material. After placement of fill and revegetation (see below), dendritic channels would be allowed to self-form. Because creating low order, steep slope channels (desirable for juvenile salmon) is extremely challenging (Dutch Slough Working Group 2004), this method could be implemented on a small-scale to determine feasibility for a much larger area (e.g. Little Franks Tract). However, during the time period between planning and implementation, techniques used at other similar restoration projects in the Delta, would be evaluated to determine their applicability at this project.

- *Limited planting of tidal marsh areas*. Pioneer marsh vegetation establishes quickly on bare soil at intertidal elevations Simenstad et al 2000). Once plants are established, they can expand to lower elevations by lateral expansion (Simenstad et al 2000). Planting densities could be greatest at potentially vulnerable areas such as those exposed to wave erosion. Other interior locations would be sparsely vegetated to allow natural colonization of native species to occur. Further details regarding revegetation and other habitat restoration components for this project would be developed as part of a detailed restoration plan.

- *Use of bioengineering techniques*. Existing remnant levees, in-channel islands, and newly constructed setback levees and fill areas supporting tidal marsh vegetation could be protected and expanded using bioengineering techniques. Treatments such as brush boxes and rootwads installed as barriers between prevailing erosive forces and remnant landforms have proven effective in stabilizing eroding areas as determined from monitoring of the In-Channel Island Restoration Project (Delta In-Channel Island Work Group 2004, Nichols et al. 2004). They also provide quiet "backwater" areas behind the structures at appropriate elevations for restoration that, because of scouring, did not formerly support tidal marsh vegetation. In the deeper waters, native marsh plants could then be installed and secured from washing away using anchored "mulch pillows." An additional advantage of installing these treatments is that they protect and create substrates suitable for colonization by special-status plants. For example, anchored rootwads installed off the shoreline of an in-channel island near Webb Tract have been colonized by Mason's lilaeopsis. Also, substantial increases in density of Suisun Marsh aster have been documented on formerly unstable shorelines behind brush boxes installed off Little Tinsley Island (Delta In-Channel Island Work Group 2004; Nichols et al. 2004).

2.3.2 RIPARIAN SCRUB/WOODLAND HABITAT RESTORATION

Identification of potentially feasible riparian scrub/woodland restoration sites within the study area is part of the habitat diversification goal of this study. Riparian scrub/woodland restoration and resulting benefits to special-status wildlife also help achieve goals and objectives of the ERP and MSCS.

OPPORTUNITIES

- *Substantially increase riparian scrub/woodland habitat through restoration*. Riparian plant communities have become rare in the western Delta. This project could potentially restore this community type through creation of landforms suitable for riparian vegetation This would primarily be accomplished by planting the top of setback levees at elevations above +4 feet NGVD. At Lindsey Slough, riparian vegetation located on a natural levee was 1' above the average marshplain elevation (Simenstad et al 2000). Riparian vegetation in the Delta typically grows at the upper end of tidal marsh at approximately or just above the MHHW level. (Atwater 1976). This acreage would replace areas that are currently open water and dominated by non-native Egeria.

- *Opportunity to restore non-native areas to native habitat*. As depicted in Exhibit 1-6, remnant levees around the perimeter of Franks Tract support both native communities (primarily northern boundary) and those dominated by monocultures of invasive weeds, particularly Himalayan blackberry (*Rubus discolor*), arundo (*Arundo donax*). Areas that are dominated by non-native vegetation could be treated and planted with native vegetation. Most of the invasive species (described above) occur above the MHHW level and therefore native vegetation would be comprised primarily of riparian species.

- *Opportunity to protect existing remnant riparian and tidal marsh habitat.* Much of the remnant levees surrounding Franks Tract support highly valuable native communities. Through construction of setback levees, these areas can be greatly protected from wave and wind erosion.

- *Add complexity to community types*. Adding rootwads, logs, and snags in both the riparian and tidal marsh communities would add diversity and complexity to these habitat types. This could be accomplished by using discarded orchard material, eucalyptus stumps, or other vegetation and securing it at the newly created area (e.g., setback levee). Materials would need to be transported to the site via boat and feasibility of this action would depend upon relative cost of transport and placement.

- *Increase native habitat for native wildlife species*. The creation of additional riparian scrub/woodland habitat could benefit native fish and invertebrates, birds, and reptiles. The provision of additional shaded riverine aquatic (SRA) habitat created by restoring riparian scrub/woodland along remnant levees adjacent to channels could benefit invertebrates and fish. Upland basking habitat provided in riparian scrub/woodland could benefit the western pond turtle and the giant garter snake, both native special-status reptile species. Riparian scrub/woodland habitat could provide wintering habitat for Neotropical migratory birds, such as Bullock's oriole (*Icterus bullockii*), and Wilson's warbler (*Wilsonia pusilla*). This habitat could also provide nesting and foraging areas several special-status avian species, such as California yellow warbler (*Dendroica petechia brewsteri)* and saltmarsh common yellowthroat (*Geothlypis trichas sinuosa*). If restored or created riparian scrub/woodland habitat included trees such as Fremont cottonwood (*Populus fremontii*), it could provide nesting rookery habitat for native year-round resident species, such as great blue heron (*Ardea herodias*), great egret (*Ardea alba*), and black-crowned night-heron (*Nycticorax nycticorax*). For additional information regarding species that may occur at the flooded islands and their habitat requirements, see Section 4.7 of the Flooded Islands Feasibility Study Baseline Report (EDAW 2005).

CONSTRAINTS

- *Potential riparian scrub/woodland restoration areas are limited by scour and shoreline erosion from high-energy currents and waves.* Hydraulic forces, such as wind waves, boat wakes, tidal flows, and fluvial currents are eroding in-channel islands and remnant levees that either support existing riparian scrub/woodland or are suitable for restoration of that habitat.

- *Difficulty in accessing suitable landforms*. Most appropriate riparian scrub/woodland restoration areas in the study area are only accessible by boat. Because of this factor, transport of materials, equipment, and staff is much more challenging. Therefore, costs of implementing this type of restoration would expect to be significantly more than land-accessible sites.

- *Uncertainties*. Uncertainties pose potential constraints in achieving goals and objectives and may include the following:

  - Quantifiable benefits to fish and wildlife from riparian scrub/woodland restoration in the Delta are not well documented because it is difficult and expensive to determine whether beneficial changes have resulted from the restoration, or from fluctuations caused by other variables (e.g., season, weather, etc.).

POTENTIAL APPROACH

- *Use of clean fill to create landforms at elevations suitable for riparian scrub/woodland restoration*. Higher portions (above +4 feet NGVD) of repaired or constructed setback levees would be suitable for riparian scrub/woodland restoration. Uncompacted fill could be installed and prepared in a manner conducive to planting native riparian scrub/woodland vegetation.

  - *Existing landforms at elevations appropriate for supporting riparian scrub/woodland habitat could be restored by removing invasive nonnative vegetation and planting native riparian vegetation*. Control techniques for nonnative vegetation could include weeding, cutting, and herbicide application. Restored areas could be designed and planted to favor native species establishment in an attempt to outcompete invasive species.

  - *Existing in-channel islands and remnant levees and newly constructed setback levees supporting tidal marsh vegetation could be protected by using bioengineering techniques*. Edge treatments, such as brush boxes and rootwads installed as barriers between prevailing erosive forces and remnant landforms supporting riparian scrub/woodland habitat, have effectively stabilized eroding areas (e.g., results from monitoring of the In-Channel Island Restoration Project [Delta In-Channel Island Work Group 2004, Nichols et al. 2004]).

2.3.3 FISHERIES

Opportunities and constraints that affect the quality and availability of aquatic habitats and the native and nonnative fish and macroinvertebrate communities that inhabit the central Delta and study areas include (1) changes in migration corridors, habitat connectivity, hydraulic circulation patterns, and water quality as a result of operations of potential gates and barriers; and (2) modifications to aquatic habitat through changes in the depth distribution and topography of subtidal and intertidal habitat.

The biological response of the native and nonnative fish community inhabiting the central Delta to habitat changes within Franks Tract is complex. Various species and life stages of fish have differing habitat preferences and requirements. These habitat preferences and requirements vary among life stages, seasons, and in response to physical factors such as tidal currents, water depths, salinity, water temperatures, as well as in response to interactions among species (e.g., predator-prey dynamics). These relationships, and the response of a given species, both positively and negatively, to changes in aquatic habitat within Franks Tract and surrounding waters is difficult to predict and quantify. In addition, the species and life-stage specific response of fish is dependant on the specific location of the habitat, proximity to deep and shallow water, the size and complexity (diversity) of the habitat, and a variety of other considerations. Based on the level of detail regarding the specific habitat conditions that would be changed or created for fish within Franks Tract as part of this feasibility assessment, detailed analyses have not been provided for each alternative, but rather opportunities and constraints are identified for use in a general assessment and comparison of potential increases and/or decreases in aquatic habitat quality and availability among alternative projects.

There has been considerable interest in the scientific community and among resource managers regarding the effects of existing tidal gate operations and changes in aquatic habitat on the survival and abundance of various fish species inhabiting the Delta. However, little quantitative information is available for assessing the direct and indirect effects of these changes on the population dynamics of native and nonnative resident and migratory fish species.

As part of the feasibility investigation, a variety of potential alternative configurations were identified that included changes in levees (e.g., closing existing levee breaches) and the use of various gate options to affect tidal circulation and salinity within Franks Tract and the surrounding central Delta. Changes in local water velocities, tidal currents, and turbulence associated with gate operations and changes in levee configurations may affect the distribution and concentration of fish, including both predatory and prey species, and the vulnerability of fish to predation mortality. Physical structures such as an operable gate or tidal barrier may also contribute to habitat cover and structure that attracts predatory fish, such as striped bass (*Morone saxatilis*) and largemouth bass (*Micropterus salmoides*), to areas within Franks Tract where predation mortality may be concentrated. Closure of levee breaches, and gate operations either daily based on tidal conditions or over a longer period of time, may also affect migration of anadromous species (e.g., chinook salmon [*Oncorhychus tshawytscha*], steelhead [*Oncorhynchus mykiss*], etc.) as well as local movements of resident fish species. The potential for increased predation mortality and/or delays, impediments, and seasonal barriers to migration and local fish movement will vary among alternatives based on the specific location and configuration of the gate or levee changes, as well as the specific seasonal and daily operations of the gates (e.g., when gates would be open or closed, expected water velocities and turbulence passing through the gates, etc.) during seasonal periods when various fish species and life stages are present in the study area. The potential effects of gates and barriers will also vary among fish species and life stages in response to factors such as seasonal migration and movement patterns, behavioral response to velocities, swimming performance, habitat preferences, response to physical structures, and a variety of other factors. Based on the level of project-specific detail developed as part of this pre-feasibility study, detailed quantitative assessments of these potential fishery effects have not been made. The project alternates offer a range of physical features and operations that could be evaluated as additional project-specific information is developed for selected alternatives, as well as operational flexibility to minimize or avoid many potential impacts to various fish species. The pre-feasibility study identifies, in general, these opportunities and constraints for use in qualitative comparisons among alternatives.

It has been hypothesized that changes in the physical characteristics of Delta channels as a result of reclamation, levee construction, channelization, and other land-use changes have substantially altered the quality and availability of shallow water habitat in the Delta. Brown (2003c) defines shallow water habitat as areas with water less than 6.6' deep at MLLW. This is approximately 9.8' MHHW. In the vicinity of Franks Tract, Big Break and Lower Sherman Lake, areas 6.6' deep at MLLW are 7' NGVD. Historically, the Delta was composed of large areas of shallow water habitat having a network of dendritic channels and extensive stands of emergent aquatic vegetation. As a result of land-use changes, habitat diversity in the Delta has been reduced, and the availability of high-quality shallow-water habitat necessary to support successful reproduction and juvenile rearing for native fish species, as well as the production of phytoplankton, zooplankton, and organic material, has been severely reduced. The reduction in habitat diversity and the availability of a variety of subtidal and intertidal habitat types has been identified as a factor contributing to the decline in abundance of native fish species inhabiting the Delta, including special-status species such as delta smelt (*Hypomesus transpacificus*), chinook salmon, and steelhead Moyle 2002; USFWS 1996; NMFS 1997; NMFS 2003). In parallel with these changes in habitat quality and availability, other changes in the Delta environment include the introduction and colonization of Delta aquatic habitat by a variety of nonnative (alien) fish, including a variety of recreationally important species, such as striped bass, largemouth bass, and channel catfish (*Ictalurus punctatus*). Study objectives to improve / enhance conditions for both native and recreationally important nonnative fish species generally are inherently conflicting; however, these conditions may offer both opportunities and constraints regarding the potential biological benefits of modifications to the aquatic habitat in the study areas. A more detailed discussion of the specific fish species that may be affected by modifications to the flooded islands can be found in Section 4.7 of the Flooded Islands Feasibility Study Baseline Report.

OPPORTUNITIES

- *Improve migratory conditions for native fish species.* Opportunities exist for gate operations to have a beneficial effect on migratory conditions for native fish species. Gate closure during the fall months may result in increased attraction flows for upstream migrating adult fall-run chinook salmon. Gate closure might also create a barrier to adult salmon migrating into the flooded islands, where their upstream migration may be delayed compared to migration within the main river channel. Seasonal closures of gates during late winter and spring may also reduce the movement of juvenile downstream migrating fall-run chinook salmon and steelhead from the main river channels into the flooded islands. This may serve as an opportunity to increase juvenile survival by reducing potential delays in downstream migration, as well as reducing potential vulnerability to predation mortality within both the breaches and open water areas within the flooded islands.

- *Improve and increase aquatic habitat diversity to benefit native and recreationally important fish species*. One fishery habitat restoration and enhancement opportunity would be the creation of additional subtidal and intertidal habitat diversity. The open water areas within Franks Tract and Big Break are characterized by a relatively uniform bottom profile with relatively little habitat diversity. Investigations of sediment deposition within Franks Tract as part of the Breach Study and other investigations have identified wind fetch and resulting wave-induced sediment resuspension as factors affecting the physical characteristics and processes within Franks Tract.

  Opportunities exist to restore tidal marsh habitat along selected remnant levees as well as within relatively shallow, confined interior open-water areas, through localized dredging and/or the importation of sand and other substrates that could be deposited strategically to create additional habitat diversity. The tidal marsh habitat could also be designed to connect with channels that provide more favorable conditions for native species.

  Depending upon the configuration and location of sediment deposits and changes to the topographic characteristics of the study areas, there would also be opportunities to create areas that may be protected from wind and wave induced resuspension. Increasing the complexity and diversity of subtidal and intertidal habitat would also provide opportunities to increase habitat quality and availability for juvenile fish rearing, as well as increase production of phytoplankton, zooplankton, macroinvertebrates, and organic materials. Colonization of the subtidal and intertidal areas by native emergent vegetation, as well as planting higher elevation areas with suitable terrestrial native plant species, would provide further habitat value for native fish and wildlife.

  New or restored levees that interface with the open water of Franks Tract could be designed to provide beneficial habitat for recreationally important nonnative fish species, such as striped bass and largemouth bass.

CONSTRAINTS

- *Changes in native fish concentrations and exposure to predation*. Juvenile and adult fish may concentrate at the existing breaches in the levee surrounding Franks Tract and other flooded islands, and, as a result of water velocities and turbulence, their ability to avoid predation may be reduced (McGowan and Marchie 1998). Operation of gates and other hydraulic control structures may result in additional concentrations of fish into a channel or passageway, increasing their exposure to accelerating velocities and turbulence, thus increasing the vulnerability of juvenile and adult fish to predation. The effect of these various factors on survival and habitat conditions within the flooded islands would vary depending on the specific design, location, and operations of the gate structure. The risk assessment to further evaluate opportunities and constraints of gate operations, and their potential effect on individual life stages and species of fish and their habitat, would depend on specific physical and operational features.

- *Barriers or impediments to migration*. Franks Tract is located within an area of the central Delta that serves as a migratory pathway for the upstream and downstream migration of a variety of anadromous fish species including chinook salmon, steelhead, striped bass, American shad (*Alosa sapidissima*), and sturgeon (*Acipenser medirostris* and *A. transmontanus*). The study area also provides habitat for a variety of resident fish species such as delta smelt, splittail (*Pogonichthys macrolepidotus*), and many others that move seasonally or in response to environmental or biological conditions (e.g., in preparation for spawning). Closure of existing levee breaches and/or closure of operable gates may create barriers or impediments to migration and local movements. The potential impact of barriers or impediments to migration vary depending on the specific seasonal and daily operation of a gate (opening and closing) relative to the seasonal timing of migration for a particular species and life stage. Closure of existing levee breaches would also reduce connectivity between Franks Tract and surrounding waters and therefore opportunities for fish movement into and out of Franks Tract. Changes in fish movement may be detrimental or beneficial to a species depending on factors such as vulnerability to predation mortality or delays in migration for fish entering Franks Tract. The assessment of effects of barriers or impediments to fish migration or local movement would depend on the specific physical and operational features of a given project alterative.

- *Nonnative fish and SAV habitat relationships*. Many areas within Franks Tract and Big Break, as well as many other locations in the Delta, have become colonized by exotic SAV. Results of fishery studies conducted within the Delta and elsewhere, although subject to a number of criticisms regarding gear selectivity and other potential biases, have demonstrated that colonization of the shallow water habitats within Franks Tract and Big Break by Egeria and other nonnative SAV create further opportunities and constraints for aquatic habitat restoration. Egeria beds serve as habitat to a variety of alien fish species, including bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), largemouth bass, warmouth (*Lepomis gulosus*) black crappie (*Pomoxis nigromaculatus*), goldfish (*Carassius auratus*), western mosquitofish (*Gambusia afinis*), golden shiner (*Notemigonus crysoleucas*), threadfin shad (*Dorosoma petenense*), and inland silversides (*Menidia beryllina*) (McGowan and Marchie 1998). Egeria beds also may provide habitat for native larval and juvenile fish and macroinvertebrates; however, these areas also appear to provide habitat potentially benefiting predatory alien fish species that may affect predation mortality for native species. Overall, there is no definitive information on the relative weight of opportunities and constraints associated with the creation of additional shallow water habitat or increased habitat diversity within the flooded islands, with or without colonization by SAV, which would clearly demonstrate the population-level benefits to the native fish assemblage. Brown (2003b) developed conceptual models for fish habitat use in Delta wetlands with and without SAV (Exhibits 2.3-1 and 2.3-2).

- *Uncertainties*. Uncertainties pose potential constraints in achieving goals and objectives and may include the following:

- Construction and operation of tidal gates or other barriers intended to improve water quality conditions in the south Delta may directly and indirectly affect movement patterns and habitat conditions for resident and migratory nonnative fish species. The breaches in the perimeter levees of Franks Tract serve as migratory pathways that allow fish and macroinvertebrates to move in and out of Franks Tract. Seasonal closure of one or more of the significant breaches and/or permanent closure of many of the smaller levee breaches would directly affect circulation patterns, tidal hydrodynamics, water quality, and conductivity between Franks Tract and surrounding Delta channels that would alter the ability of fish to move among habitats. The effect of these changes in habitat conditions as a consequence of seasonal closure of gates or barriers would vary within and among species based on the seasonal occurrence of various life stages of the species in the central Delta coincident with the seasonal period of gate closure. The effects on fishery habitat and movement patterns would be further complicated by daily closure of an operable gate in response to tidal stage.

- Changes in circulation patterns and tidal hydrodynamics have the potential to affect phytoplankton and zooplankton species as well as the suspension and downstream dispersal of planktonic fish eggs and larvae.

POTENTIAL APPROACHES

< *Restore native habitats and habitat diversity for native fish species*. Restoration of additional subtidal and intertidal marsh habitat and increased habitat diversity offers both opportunities and constraints that will vary depending on the specific size and location of the habitat features, their physical characteristics, and the interaction between these habitat features and the hydrodynamics and tidal circulation, water velocities, sediment deposition and erosional patterns, water quality, and other physical and biological processes. Assessment of the specific opportunities and constraints for habitat restoration, in combination with other elements, will be dependent on the specific characteristics of the proposed actions.

2.3.4 INVASIVE AND OTHER NONNATIVE SPECIES

Identification of criteria to control and reduce the spread of nonnative species inhibiting their negative economic and ecosystem impacts within the flooded islands is a goal of the Feasibility Study. Invasive or nonnative species of particular concern in the area include *Egeria densa* and *Corbicula fluminea*. Exhibit 2.3-3 presents an aerial photograph of Franks Tract showing Egeria distributions in September 2002. A more detailed discussion of nonnative species that may be affected by modifications to the flooded islands can be found in Section 4.8 of the Flooded Islands Feasibility Study Baseline Report.

EGERIA DENSA AND WATER HYACINTH

Submerged aquatic vegetation (SAV) is characterized by rooted vascular plants that occur within shallow to deepwater habitats of slow-moving or still waters. The primary factor determining the presence, composition, and amount of all SAV is the intensity of light available for plant growth. SAV within the open water of the flooded islands is dominated by the nonnative species *Egeria densa*. Egeria is in the waterweed (*Hydrocharitaceae*) family and is typically rooted to a substrate but its stems may grow up to 20 feet long to reach the water's surface. The plant may also occur as free-floating mat or as floating fragments at or near the water's surface. When conditions are appropriate the uncontrolled growth of this species results in the formation of dense homogeneous stands that cover large expanses. Egeria also provides a large substrate upon which filamentous algal mats form that otherwise would not be there. The dense Egeria stands combined with the algal mats to completely or partially "seal off" the air/water interface and restrict gas exchange and access of waterfowl to the sediments (Anderson pers. comm., 2005).

Egeria can intrinsically alter water flow and ecosystem processes. It also obstructs navigation, which hinders recreational and commercial opportunities for swimming, boating and fishing. Egeria currently infests approximately 6,000 acres of waterways throughout California (DBW 2004). Successful methods for eradicating Egeria have not been identified (DBW 2001 and 2004).

Other SAV that occurs in the Delta include the non-indigenous Parrot's Feather (*Myriophyllum aquaticum*), and the natives water primrose (*Ludwigia peploides*), coontail (*Ceratophyllum demersum*), and various types of pondweed (*Potamogeton* spp).

Floating aquatic vegetation (FAV) grows in freshwater lakes, rivers, and ponds, as well as estuaries with low salinity levels. These freely floating beds of vegetation are located within the water column or on its surface. Native FAV include duckweed (*Lemna* spp.), water meal (*Wolffia* spp.), and algae. The dominant FAV within the flooded islands is the invasive nonnative species water hyacinth (*Eichhornia crassipes*). This plant readily forms dense, interconnected mats that drift along the water's surface. This species can tolerate a wide range of water levels, flow velocities, and extremes in nutrient concentration, pH, and temperature (Batcher 2000).

OPPORTUNITIES

- *Reduce Egeria and water hyacinth densities within open water areas.* The creation of tidal marsh and riparian scrub/woodland habitat would replace existing open water habitat that currently contains a high density of Egeria and limited amounts of water hyacinth.

- *Potentially reduce Egeria success within open water areas.* Several factors that could affect Egeria success could be manipulated including depths, light levels, salinity concentrations, and substrate. Manipulation of these conditions could reduce habitat suitability for Egeria, thus reducing the ability for Egeria to succeed in the study areas.

  Egeria can live in depths down to -12 or -14 and up to -3 or -4 feet, as measured at high tide. Franks Tract could be dredged below -12 to reduce suitable habitat, and restored areas could be designed to avoid depths between -3 and -12. Egeria can withstand 10 to 12 parts per thousand (ppt) of salt water for up to a few days or 8 to 10 ppt for several weeks during the main growing season and even longer in the fall (Anderson, pers. comm., 2004). If salinity levels within Franks Tract exceeded these levels for periods of time, the Egeria population may be reduced; however, this magnitude of change would likely result in potentially significant ecosystem responses. Egeria cannot become established on unconsolidated sandy substrates (Anderson, pers. comm., 2004); therefore, restoration efforts could include the use of sandy substrates to discourage the growth of Egeria.

< *Opportunity to establish native SAV is constructed backwater areas*. As part of the construction of the levee setback areas and open water areas adjacent to Little Franks Tract, small areas may be suitable for establishing and testing the persistence of native SAV species. Establishment of native SAV communities may exclude invasion by Egeria in these areas.

< *Increase understanding of influences of habitat on susceptibility to invasive aquatic species*. Opportunities exist to increase understanding of influences of specific habitat conditions on susceptibility to invasive aquatic species through monitoring, research, and adaptive / experimental management.

Constraints

< *Activities resulting in potential increased Egeria growth*. Egeria poses a constraint to restoration in that it is a natural successional plant with a range of tolerance of environmental conditions. The primary means of reproduction and dispersal of Egeria is fragmentation of shoots and rhizomes; therefore, construction or restoration activities in or near Egeria-infested areas could result in Egeria colonizing new areas.

< *Efforts to increase flows and inhibit Egeria may simply move the infestation elsewhere*. High water velocities prevent Egeria establishment. Growth is inhibited where there is wind and wave action. (Anderson pers. comm., 2004). Erosion control efforts where native plant species are not yet established may create a stable environment and a new area for infestation.

< *Egeria outcompete native SAV flora*. Egeria occupies the same niche as native SAV species; however, restoration of native SAV flora cannot be achieved by hydrodynamic means alone without a massive decrease of Egeria. As long as Egeria is well established at a given location, its canopy in the water column will allow it to outcompete native flora.

< *Uncertainties*. Uncertainties pose potential constraints in achieving goals and objectives and may include the following:

- Several ecological effects of Egeria are not well understood; however, a recent study shows that advances in the understanding of how SAV influences hydrodynamics are underway (Serena and Stacey 2004). While the referenced study shows that Egeria can have significant effects on water velocities, vertical exchange, and possibly localized residence times, it is not well understood how Egeria affects larger scale mixing, if

Egeria increases sedimentation, or if Egeria encourages or hinders phytoplankton growth.

POTENTIAL APPROACHES

< *Experimental dredging and adaptive management.* Experimentally evaluate different dredging methods and maintenance requirements for a range of management objectives.

< *Physical and chemical control of Egeria.*

< *Create environmental conditions that are not suitable for Egeria establishment.*

- Create tidal marsh at elevations not suitable for Egeria establishment.
- Actively plant and establish native plant species in areas that have potential to support Egeria colonization.
- Create dendritic channels with suitable flows and velocities to prevent Egeria colonization.

CORBICULA FLUMINEA

Corbicula fluminea is a prolific invasive freshwater clam native to Asia that has become the most widespread and abundant freshwater clam in California. Corbicula is primarily a filter feeder, straining out and eating microscopic food particles in the water. It lives in stagnant as well as flowing waters of varying depths. Corbicula competes directly with native benthic species, and indirectly with non-benthic native species in other trophic levels of the food chain, like zooplankton and fish species, by consuming phytoplankton.

OPPORTUNITIES

< *Reduce Corbicula densities within Franks Tract*. The creation of tidal marsh and riparian scrub/woodland habitat unsuitable for Corbicula would replace existing open water habitat which currently contains large numbers of Corbicula, thus reducing their total number. Corbicula densities within Franks Tract could also be reduced by large scale dredging of the sediments containing Corbicula. However, this may result in a temporary reduction because Corbicula could quickly recolonize the area.

< *Reduce Corbicula success within Franks Tract*. Although it is not likely that densities of Corbicula could be significantly reduced in Franks Tract, three possible stressors to the Corbicula could occur: increases in salinity levels, decreases in dissolved oxygen (DO) levels, or temperature changes. These stressors could reduce habitat suitability for Corbicula in Franks Tract, thus reducing its success and impacts to the ecosystem. Although Corbicula are tolerant of saline waters, increases in the salinity of Franks Tract above 17% could make it unsuitable for the clam. However, this alteration could create

suitable habitat for the invasive saltwater Asian clam, (*Potamocorbula amurensis*), which could fill the niche left by the reduction of Corbicula.

Although large scale DO changes in Franks Tract would be unlikely, changes that could create short term "layers" or "pockets" of low DO could possibly stress or kill individuals. Substantial temperature changes within Franks Tract, either seasonally or annually, could decrease metabolic or reproductive functions of the Corbicula. Other factors that could affect Corbicula population densities (e.g., chlorine, copper sulfate treatments, periodic drying) would not be suitable for use within a natural tidal ecosystem.

CONSTRAINTS

< *Corbicula presence could counteract phytoplankton increases*. In Franks Tract, Corbicula are likely food limited; therefore, any efforts made to increase phytoplankton production within Franks Tract could be counteracted by the presence of large numbers of Corbicula that occur within Franks Tract. It is possible that an increase in phytoplankton production would simply increase the size of individual clams or Corbicula populations until net phytoplankton production within Franks Tract reached an equilibrium near current levels; however, short duration blooms may be possible.

< *Uncertainties*. Uncertainties that pose potential constraints in achieving goals and objectives and may include the following:

- Little is known about Corbicula effects on the ecosystem including interactions with other invasive species including Egeria; this is primarily because of the lack of ecological studies preceding its invasion. The effects of increases or reductions in Corbicula densities or success are not certain. Baseline studies of Corbicula within Franks Tract could be compared with monitoring results following alternative implementation.

Potential Approaches

< *Study the lack of Corbicula within Mildred Island*. To reduce uncertainties about ecosystem effects of Corbicula and to investigate potential control methods, further study of the absence of Corbicula within Mildred Island would be beneficial. Methods for adaptive management of conditions within Franks Tract would allow for alterations of conditions, following the results of research at Mildred Island.

< *Provide for adaptive management*. Design of an alternative should provide for adaptive management strategies based on results of monitoring within Franks Tract and research at Mildred Island.

2.4 RECREATION ISSUES

This section evaluates opportunities and constraints, and identifies potential approaches for boating access, navigation, maintaining open water, and other recreation-related activities within the Flooded Islands Feasibility Study area.

2.4.1 BOATING ACCESS AND NAVIGATION

The interconnected network of natural sloughs and constructed channels in the Delta are essential travel corridors for recreational boats of all types and sizes. Boats commonly travel considerable distances on these waterways, as well as use them for more localized travel. Houseboaters and others with large boats suitable for overnight stays may travel in the Delta over several days or weeks. Bass anglers rove over long distances in pursuit of the best fishing. The sloughs, cuts, and channels that surround and, in the case of Sherman Lake, cross the study sites are important as boat thoroughfares and as the means of access to marinas, boat docks and ramps, and other facilities used by boaters. Potential improvement elements may have the potential to create access barriers and navigation hazards. However, other actions proposed as ecological restoration and recreation elements may present opportunities for enhancing navigation.

OPPORTUNITIES

- *Maintain boating access.* Opportunities exist to construct potential features while maintaining important boating access points and routes. Access and free movement of traffic between the open water and the sloughs and channels are important for recreation use. At Franks Tract, the Bethel Island side of Piper Slough on the west side of the site is lined along its entire length with commercial marinas, resorts, and private boat docks associated with levee-side homes. Boats generally cross the open water of Franks Tract through gaps in the remaining levee remnants due to the convenience of reaching areas on the other side of Franks Tract or specific areas within the Tract. Sand Mound Slough and Dutch Slough, along the south side of Bethel Island, and Taylor Slough, on the west side of Bethel Island, are likewise lined with marinas and docks.

- *Dredging of deep navigation channels.* Bethel Island marina owners have suggested that several boating channels be dredged across Franks Tract to provide deeper water for boat passage and prevent growth of Egeria. Such channels would enhance navigation across Franks Tract, particularly for larger boats. A related proposal is to construct linear islands along side the dredged channels, using dredged material from the site or brought in from elsewhere. The intent of these islands would be to reduce wave fetch, decrease resuspension of bottom sediment, and lessen subsequent filling in of the dredged boating channels. The islands could potentially also provide opportunities to develop sheltered boat mooring sites and could provide wildlife viewing opportunities associated with the created island habitat.

CONSTRAINTS

- *Construction of permanent barriers in channels and waterways*. Potential site modifications that include permanent barriers could have an adverse effect on recreation by blocking boat traffic circulation. Installation of barriers across Delta sloughs and channels could force boat traffic to use other routes and in many cases could greatly increase travel distance between destinations for boaters.

- *Construction of operable tidal gates in channels and waterways*. Operable tidal gates impose varying degrees of limitation on boat traffic, depending on their design. These types of structures, similar to permanent barriers, could impede boat movement and access. When locks are in operation in any area with moderate or heavy boat traffic or during peak weekend and holiday boating periods, they may be expected to cause lengthy delays and congestion.

- *Repair and reclamation of remnant levees and levee gaps*. Levee repairs may have negative effects on boating access. Closing gaps in the levees used by boaters to gain access to open water areas and to move back and forth between those areas and adjacent river channels and sloughs may reduce boating access. Assuming some gaps would remain, boaters would continue to cross between sloughs and open water areas, but those who had used gaps closed during levee repairs would have to travel greater distances to enter the open water areas or to reach boating facilities on nearby river channels and sloughs.

- *Increased growth of submerged aquatic vegetation*. The problem of SAV infestation in the study area and its effects on boating access is not directly related to conceptual improvement elements, but may be affected by them. Many sloughs (as well as shallow and slow-moving open water areas such as exist at the flooded islands) are heavily infested with Egeria (see Section 2.3.4, "Invasive and Other Nonnative Species," above), which has greatly reduced the ability of most recreationists to use these areas. During summer, profuse branching forms a canopy of dense, tangled mats on the water's surface that interferes with navigation, fishing, swimming, and water skiing. The plant material easily clogs boat propellers, potentially stranding boats. Some Egeria that is entrained and removed at the SWP's and CVP's export facilities in the south Delta near Tracy is thought to originate from Franks Tract. The Egeria problem at these facilities becomes significant enough that it prevents these facilities from operating properly. At times, the water export operations must be stopped until the debris at these facilities can removed. Egeria tends to form pure stands that can cover hundreds of acres and can persist until the fall.

  The plant is a target of an extensive removal and control program in the Delta, implemented by the Department of Boating and Waterways (DBW 2001). Sandmound Slough and Piper Slough near Franks Tract and Dutch Slough near Big Break are sites targeted by the program, in part because of the problems caused by weed growth for boat navigation in the sloughs and the resulting loss of access to and usability of marina and dock facilities in those areas. Some potential elements may have the potential to exacerbate the Egeria problem if they increase areas of shallow and slow-moving water. The effects of Egeria infestation in the open water areas and additional details on current control efforts are provided in Section 2.4.2, "Maintain Open Water," below.

- *Changes to flow patterns (creating navigation hazards) resulting from barriers, gates, and levees*. Barriers, tidal gates, locks, and levee repairs would affect the flow of water and can have the unintended consequence of creating boating hazards in the form of more rapid and more variable flows than would have existed before these changes were made. In particular, structures or levee repairs that restrict flow can cause areas of fast currents and eddies that are challenging for boaters to navigate and that they may enter into unaware of the hazard. If creation of such hazards proves unavoidable, boaters may not be allowed in areas where the hazards exist, reducing their movement through and use of the Delta.

- *Costs, permitting, and environmental impacts associated with dredging*. Suggestions by recreation stakeholders to dredge boating channels across Franks Tract would potentially be constrained by several factors. First, dredging is expensive and could be delayed because of permitting requirements and restrictions. It is likely that the channels would fill in rapidly, given the exposed nature of the area and the high-velocity currents that pass through the area. This would require repeated channel maintenance dredging, which would impose an ongoing permitting and cost burden on DPR. Second, it is unknown if the material dredged from Franks Tract could be used on-site for the creation of other potential elements. If the material dredged is largely composed of peat soils, the material may be unsuitable for construction and may need to be disposed of at another site. Off-site disposal would impose additional permitting requirements and costs.

POTENTIAL APPROACHES

- *Locate gates/barriers away from main navigation channels and access points*. Many of the conceptual improvement elements may have the potential to negatively affect boating access. However, the specific implementation of the elements in terms of design, location, and other factors would determine the extent and significance of the effects. Gates/barriers could cause unavoidable negative impacts, and these may be a significant inconvenience if the barriers are placed in well-traveled locations. Enhanced access by newly created routes or levee cuts may mitigate for these effects.

- *Incorporate navigation locks or boat ramps into potential barriers and gates*. Improvement elements, such as operable tidal gates, should include locks or boat ramps for passage of recreational boats. However, locating these gates and locks/ramps in primary travel routes with moderate or heavy traffic may cause significant delays and congestion. Factors such as the size of the locks (and thus the number of boats that could be locked through at a time) and how the locks or ramps are operated would also affect the magnitude of the effects of tidal gates on boating. Additional information on the amount and characteristics of boat traffic at key locations and times is needed to fully evaluate the potential effects of gates and locks/ramps in specific proposed locations. Ongoing, long-term boat traffic and visitor satisfaction monitoring are recommended.

- *Incorporate recreational facilities (e.g., beaches and mooring areas) into new or repaired levees*. Levee repairs may restrict boat traffic into and out of the open water areas of the flooded islands, but could also be designed to provide recreational opportunities. Some boaters in the Delta have expressed a strong desire for more beach and boat mooring destinations (DBW 2002). The relatively few existing beach and boat mooring sites are very popular with boaters during the summer peak boating period. Repaired levees along sloughs and on the inside of the flooded islands may be constructed with new beach areas most desired by boaters.

These sites might also feature additional amenities, such as landing docks, mooring buoys, floating restrooms, and levee-top or beach picnic sites. Additional discussion of these potential recreation enhancements is provided in Section 2.4.3, "Provide Enhanced or New Recreational Opportunities," below.

- *Carefully consider potential elements that may result in increased SAV growth*. An important component of maintaining boating access is controlling the spread and reducing the areas severely affected by infestations of SAV. Chemical and mechanical control methods are currently used, but the problem persists and may be worsening. Actions that would have the consequence of creating additional slow-moving and shallow water habitat for the invasive weeds may worsen the existing problem. Control of invasive water weeds may likely be necessary into the future, at a minimum in sloughs where navigation and use of boating facilities is severely affected.

- *Implementation of boater safety, education, and awareness program*. Several design features and actions can be included in planning for potential improvement elements to protect and enhance safe navigation. Hazard areas near gates and locks and near repaired levees would need to be publicized to increase boater awareness and thoroughly marked and restricted to provide boaters with ample warning. Coast Guard regulations require lighting on fixed structures, such as the one at the Montezuma Slough gate. Marker buoys would serve to identify flow hazard and shoal areas created by new gates, locks, or levees. Maintenance of warning buoys in the active hydrodynamic environment of the Delta may prove to be particularly difficult and expensive. The potential may exist for buoy maintenance to be performed in conjunction with the many activities performed by DPR, DFG, DWR, and other state agencies in the Delta, providing possible efficiency benefits and reducing costs.

- *Design new and reclaimed (repaired) levees to be adequately visible*. New and repaired levees would need to be adequately visible to boaters. The potential may exist to construct riparian scrub and shallow tule marsh habitat along restored levees, which would provide a visible safety buffer from boat traffic in addition to providing ecological benefits.

- *Target dredging to shallow water areas that are currently infested with SAV*. Actions that increase shallow water areas and that create more areas susceptible to Egeria infestation could be targeted for dredging and Egeria control treatments as mitigation for those effects. Both mitigation actions may be constrained by regulatory and cost factors.

2.4.2 MAINTAIN OPEN WATER

Boaters use the large open waters of Franks Tract, Big Break, and Lower Sherman Lake for recreational activities, such as fishing and hunting. These areas are particularly renowned among anglers for trophy black bass and striped bass, and fishing tournaments are held in these areas year-round. Keeping these areas open would continue to support these boating-based activities within the study areas. Opportunities also exist to enhance motorboating opportunities in these open areas by deepening them and addressing Egeria infestation problems. This would create safe, deep open water areas suitable for boating activities, such as houseboating, waterskiing, jet skiing, and sailing, activities that have been severely restricted or eliminated because of Egeria infestation. Egeria removal and dredging could also provide places for mooring boats, a facility need identified in the 2000 Sacramento–San Joaquin Delta Boating Needs Assessment (DBW 2002).

Maintaining open water at Franks Tract is particularly important for recreation. Franks Tract is sometimes referred to as the "heart" or "crossroads" of the Delta because of its central location, the proximity of major river and slough travel routes, and the many nearby boating facilities. The open water area was formerly used by all types of motorized boats and sailboats, but is no longer suitable for these boats because of the Egeria that has become established across much of the area. There is also concern that the Egeria is increasing the rate of sedimentation and/or sludge accumulation at Franks Tract, which may worsen Egeria and other navigation problems.

OPPORTUNITIES

< *Dredge boating channels*. The recreation stakeholders' proposal to dredge boating channels across Franks Tract, as described in the previous section, would not change conditions across most of the open area such that the range of former boating activities could resume, but it would enhance passage at least temporarily, by boats through the open water area and allow a wider range of activities in those channels.

CONSTRAINTS

< *Nonnative SAV growth that interferes with navigation*. There are several constraints that could affect the preservation and/or enhancement of the existing large open water areas. Constraints that are already affecting the open areas may include sedimentation and/or sludge accumulation in shallow water as well as (and in combination with) Egeria growth. As mentioned in Section 2.4.1, "Boating Access and Navigation," the open water areas, such as those at the flooded islands, are heavily infested with Egeria, which has greatly reduced the ability of most recreationists to use these areas. The water depths of the open areas are 10 feet or less and may be becoming shallower from sedimentation. Egeria generally grows at depths less than 12 feet; therefore almost all open water areas in the study area are at risk of infestation. These infestations may be a factor in increasing sedimentation of the flooded islands, which could worsen the Egeria problem and may eventually further restrict navigation and exacerbate water quality and ecological problems.

< *High costs and temporary results associated with current SAV control methods*. The DBW *Egeria densa* Control Program (EDCP) chemically treats over 1,500 acres most years at 35 sites throughout the Delta (DBW 2001). In addition to the sloughs mentioned in Section 2.4.1, "Boating Access and Navigation," open area target sites include 23 acres at Sherman Lake, 81 acres at Big Break, and 158 acres at Franks Tract. (The infested areas at *these* sites are much more extensive than the limited areas targeted for control. For example, Egeria covered 724 acres of open water areas at Big Break in 2000).

The cost of these treatments is a constraint, largely as a result of the regulatory requirements of implementing the program. A case study at Big Break estimated costs at approximately $1,000–8,700 per acre for treatment of 170 acres, depending on the chemical used (Frieman, et al. 2004). Some environmental organizations have opposed chemical control methods and have advocated greater use of mechanical control methods, such as harvesting (Campbell 2000). Mechanical control methods are labor intensive and thus expensive (the Big Break case study estimated the cost for harvesting to be about $2,400 per acre). Harvesting poses problems with disposal of removed plant material, and may increase the spread of Egeria when cut pieces of plant that are not collected migrate to and establish in new areas. The EDCP uses mechanical harvesting primarily for emergency use to gain immediate control of an area (DBW 2001).

Chemical and mechanical control methods are temporary measures that require repeat treatments; each site is treated one or more times per year. These methods have not been effective in stopping the spread of the weeds, but have kept some priority areas partially cleared and slowed the spread somewhat.

Winds and shallow depth (for some boat types) currently hinder mooring at Franks Tract and would require dredging (to 12 feet for sailboats), Egeria removal, and wind barriers to provide a good mooring area. Dredging constraints are discussed in Section 2.4.1, “Boating Access and Navigation.” Expanded chemical treatment or removal of Egeria beyond the relatively limited current EDCP target area, though beneficial to boating, would be expensive and require frequent control efforts. Dredging and Egeria removal may also result in temporary disruptions to recreation and could result in temporary negative affects on water quality.

< *Changes in hydrology resulting from improvement elements.* Future constraints on the use of open water areas include levee repairs and potential user conflicts. Levee repairs may reduce water velocity through portions of the flooded island sites and may cause areas to become more susceptible to weed growth. As discussed in Section 2.4.1, “Boating Access and Navigation,” any actions that increase shallow and protected water areas could increase habitat for SAV and subsequently exacerbate navigation and other recreation problems associated with Egeria.

< *Changes in residence time resulting from improvement elements.* Potential features (repair of levees and operation of gates) may increase residence times and therefore create stagnant water. These conditions may result in increased Egeria growth and algal blooms, which would have negative navigational, visual, and odor impacts on boating in the open water areas. Constructing the windbreak islands within Franks Tract as suggested by some recreation stakeholders would reduce and fragment the open water areas; however the site is large enough to also support large open water areas. As with levee repairs, these islands may result in increased Egeria growth by creating more sheltered growing conditions for the weed.

POTENTIAL APPROACHES

- *Focus dredging and Egeria control efforts to strategic locations that maximize benefits.* Overall, the potential exists to create mooring sites and a more boater-friendly open area in concurrence with Egeria removal and dredging. Although these actions would be beneficial for motorboating, cost and maintenance responsibility would need to be further investigated to define how much area could feasibly be altered and maintained. Long-term monitoring of visitor satisfaction and perception, boat traffic and congestion, type of boating use, and any conflicts or accidents would help identify problems among users.

- *Integrate mooring areas with other recreational facilities and amenities.* Mooring areas could also be created in concurrence with other amenities, such as pocket beaches created adjacent to new levees. Mooring areas would be most advantageous at Franks Tract because of higher use at this site and potential for other amenities, such as beaches, to be located there. These amenities could be developed in association with the mooring areas.

- *Provide alternative recreation experiences through the creation of increased tidal marsh.* Although large-scale marsh restoration would eliminate boating over what are now large areas of open water, recreational opportunities for anglers and hunters might still be provided by channels in the restored marshlands. Restored marshes could also help meet demand for more areas to enjoy canoeing and kayaking and would enhance opportunities for wildlife viewing. This option would retain much of the boating and fishing access and use at the sites, while potentially enhancing opportunities for nonpowered boating and wildlife viewing.

- *Conduct monitoring and surveys to better understand and define recreational issues and needs.* Ongoing monitoring and visitor surveying would provide information about recreationists, such as perceived and actual conflicts, safety issues, and overall satisfaction with availability of open water.

2.4.3 PROVIDE ENHANCED OR NEW RECREATIONAL OPPORTUNITIES

Within the study areas, opportunities exist to enhance boating, fishing, camping, wind/kite surfing, hunting, and wildlife viewing experiences as well as the overall recreational experience. Primarily, these enhancements would include new facilities and habitat restoration, coupled with maintenance of existing opportunities, such as open water boating. The Sacramento–San Joaquin Delta Boating Needs Assessment, (DBW 2002) conducted from 2000 to 2002, established that strong public demand exists for several types of recreational boating facilities in the Delta. A lack of landing sites and land-based day-use recreation areas was identified as a main impediment to boating. Other facilities that many boaters considered to be inadequate included public restrooms, overnight moorings, nonmotorized boating access, and launch ramps. Boaters expressed a need for more refueling locations and holding tank pump-out stations for cruisers and houseboats.

OPPORTUNITIES

< *Incorporate recreation and other facilities into other improvement elements.* Boating and fishing are the primary activities in the study area and are economically important activities in the Delta. Enhancements to boating facilities and navigation would benefit both pleasure boaters and boating anglers. Tidal gates, which could be constructed to improve water quality, could also provide opportunities for recreational enhancements. Locks for boat passage would be a necessity for tide gates installed in the well-traveled sloughs in and near the study sites. With the expectation that locks would require boaters to queue up and wait to pass through the lock, the opportunity presents itself to include nearby facilities. Basic facilities associated with locks could include floating courtesy docks and nearby picnic sites and restrooms. More substantial amenities might include a small store selling bait and fishing supplies, snacks and beverages, and boating provisions; a pump-out station, and a gas station.

< *Expand facilities to accommodate, improve, and better promote fishing tournaments. Opportunities* to enhance special events, such as bass tournaments, may include additional boat launches, on-water grandstands, maintaining open waters, and providing floating restrooms. More boat launches could help speed up launching for the several hundred anglers who participate in the larger fishing tournaments. Although some tidal marsh restoration would provide more edge marsh to fish along, open water areas are also important spaces for anglers and other boaters, especially during large tournaments with hundreds of participants. Floating restrooms would reduce the need for anglers and other boaters to return to a marina for such facilities.

< *Enhance wildlife viewing opportunities.* Wildlife viewing is another valued activity of recreational boaters and boat anglers. Opportunities exist to enhance wildlife viewing opportunities for study area visitors, particularly at Franks Tract. (The Lower Sherman Lake and Big Break sites have comparatively more marsh habitat, islands, and levee remnants to support birds and other wildlife than does Franks Tract.) Restoring tidal marsh habitat may attract a larger number and greater variety of native wildlife to the area for public viewing. Small floating platforms and walkways could be placed in and near marshes for visitors to use as bird-watching sites. These sites would be closed as needed to preserve wildlife and habitat (e.g., during nesting seasons). Wildlife viewing enhancements may also work in conjunction with new educational and interpretive opportunities and day-use facilities (explained further below).

< *Enhance wind-/kite-boarding opportunities.* Wind-/kite-boarding enhancements could include more beach launches and maintenance of open water areas. Currently Sherman Island provides a few informal beach day-use/launch sites.

< *Enhance hunting opportunities.* Waterfowl hunters use all three study sites. Waterfowl hunting may be enhanced by adding more hunting blinds and restoring tidal marsh habitat. (DPR requires that blinds be removed by hunters at Franks Tract after the hunting season, and East Bay Regional Park District [EBRPD] permits hunters at Big Break to use boat-based

blinds only.) Restoration of habitat could attract more waterfowl to the area and therefore increase hunting success.

- *Increase and improve the availability of general visitor facilities.* The overall recreation experience may be enhanced by providing more basic facilities used by all visitors. These facilities could include floating restrooms and restrooms near tide gate locks, as mentioned above. Restrooms are only available at marinas and at the Sherman Island Park launch. Floating restrooms and restrooms at tide gate locks may save visitors' time and gas by providing convenient facilities closer to where they recreate.

- *Improve and increase the availability of camping facilities.* Opportunities also exist to enhance public camping, nonmotorized boating, day use, and education and interpretation. The only public camping opportunity in the study area is an RV camping area at Lower Sherman Island Park, operated by Sacramento County. This camping area does not have designated sites or facilities other than restrooms and a few picnic tables. There are camping opportunities at many of the area's privately owned marinas and resorts. Two potential public camping facilities may be introduced, floating campsites, which would provide a unique on-water camping experience, and boat-in campsites, which would offer a land-based boating-access-only camping opportunity.

- *Improve and increase the availability of day-use facilities.* Formal day-use facilities are severely lacking in the study area; the only facilities consist of one picnic site at the Lower Sherman Island Park launch ramp and informal beaches near the Lower Sherman Island Park camping area. These are generally used by windsurfers as launch points. Although there are no existing facilities at Big Break, EBRPD is currently constructing access roads, parking, restrooms, and an observation/fishing pier. There are no public day-use facilities at Bethel Island near Franks Tract, nor any within the Franks Tract study site. Day-use opportunities may be created by adding beaches and picnic sites at appropriate locations (e.g., adjacent to levees and at gate structures). Floating picnic sites may be incorporated into the floating wildlife viewing platforms located near marshes and in other wind-protected areas. Beaches are in short supply in the Delta area; therefore any beaches created could become very popular. Beach and picnic day-use facilities would offer motorboaters, nonmotorized boaters, and anglers a place to stop and enjoy the landscape, get out of their boats, eat lunch, relax, sunbathe, and swim. These amenities could also attract and provide for the needs of families, which have been recognized as a deficit in the Sacramento–San Joaquin Delta Boating Needs Assessment (DBW 2002).

- *Improve and increase facilities and enhance opportunities for nonmotorized boating.* Although there is a large amount of boating within the study area, it is primarily motorized boating with few opportunities for nonmotorized boating, such as flatwater kayaking or canoeing. Nonmotorized boaters generally prefer quiet, calm areas away from louder, faster, wake-producing motorboats. There is some nonmotorized boat use within Piper Slough; however these users do not venture into Franks Tract because of Egeria infestation. A small nonmotorized boat launch could be created specifically for these boaters because they typically hand launch or car-top launch their boats and do not need the larger paved ramps that trailer launched boats require. Restoration of tidal marsh would offer nonmotorized boaters interesting, serene places to boat in, with plenty of opportunity to escape from motorized boat traffic (other than small fishing boats). Day-use facilities along levees would provide additional activities and destinations for nonmotorized boaters, enhancing their overall experience. Additionally, Egeria removal within Franks Tract may help make the area more inviting to nonmotorized boaters.

- *Enhance educational and interpretation opportunities.* There are few or no formal opportunities in the study area for education and interpretation because of a lack of facilities and programs. The Delta Science Center proposed at Big Break is a collaboration between EBRPD and Los Medanos College that would help meet this demand. Visitor and school educational programs are planned for this facility. Throughout the study sites, signage for safety and interpretation could be installed. Potential topics include boating safety, water hazards, navigation/traffic direction, regulations for boating, fishing and hunting, flow dynamics, significance of water in the Delta, restoration activities, typically observed wildlife and vegetation, and history of the site. A boating interpretation route or self-guided tour could lead visitors to different areas within a site as they follow signage to tidal marshes, wildlife viewing platforms, historical markers, and picnic/viewing areas.

- *Public stewardship outreach and education opportunities.* Opportunities exist to develop and fund ongoing programs aimed at engaging the public and private stakeholders in integrated "environmental stewardship" to help ensure the long-term success of potential improvement / restoration efforts.

CONSTRAINTS

There are numerous constraints currently present and possible in the future that may limit opportunities for enhancements and new facilities. These constraints include cost and maintenance, lack of land base within the study area, access, erosion, wind–wave fetch, jurisdictional limitations on development, hunting density, Egeria, user conflicts, and traffic.

- *High capital and maintenance costs associated with facilities.* Cost for some facilities may be a limiting factor that alters the size, location, or feasibility of installation. Initial costs and routine maintenance costs could be high for facilities such as floating campsites, docks at day-use sites, floating restrooms, floating wildlife viewing/picnic platforms, beaches, and facilities at locks. There are no maintenance operations set up at any of the three study sites, although the Lower Sherman Island Park is maintained by Sacramento County. Maintenance personnel, equipment, location, storage, and disposal would all have to be addressed before facilities could be installed, whether maintenance were provided by the public managing agency or contractors. Trash collection may also be a maintenance issue if new facilities are installed. Providing facilities at locks may be costly to design and maintain. Their feasibility would require additional study to determine if they are possible, considering water flow, safety, space available, and boat traffic.

< *Lack of upland sites/opportunities.* Lack of land base within the study area severely limits the potential to provide land-based facilities, such as boat-in campsites, boat launches, and hunting blinds. There is almost no public land within the study area that is not developed or in development for such facilities. Along with a lack of public land, there is very little road access to the study area, and most of it is already developed. The access to Sherman Lake is already developed, and access to Big Break is currently in development. There is no direct road access to Franks Tract, although road access is available to the facilities lining the adjacent Piper Slough. The lack of public land and road access limits building additional new boat launches, or beach launches for wind/kite surfers.

< *Natural elements, erosion, and sustainability of facilities and amenities.* Erosion, a common problem for facilities at water-based sites, may affect potential locations for beaches, picnic areas, docks, and signage. Erosion could have an impact on maintenance costs for these facilities by affecting how often sand would have to be added to beaches, picnic areas, or around docks, or how often signs would need to be moved. Wind–wave fetch can also be an issue in the study area. This could affect location and feasibility of floating wildlife viewing/picnic platforms, floating campsites, floating restrooms, signage, and picnic sites located on levee tops. Location and orientation of these facilities would be important.

< *Multiple jurisdictions, political boundaries, and integration of policies.* Another constraint is jurisdictional limitations on new development. Increased recreational development may conflict with the policies of public agency landowners, including DPR, DFG, and EBRPD, or may conflict with these landowners' vision of the study sites. New facilities, although beneficial for recreation, may be an increased burden on these agencies' in terms of liability (e.g., beaches, hazard signage) and maintenance (e.g., floating campsites, restrooms), and may add management costs that cannot be meet under current budget constraints. These budget limitations are likely to be permanent or long-term factors.

< *Maximum hunting densities.* Hunting density could be a constraint to adding more hunting blinds. Permits for additional temporary blinds are unlikely at Franks Tract because the number of blinds is already at peak safety density as determine by DPR (DPR 1997). EBRPD does not allow permanent blinds (DPR 1997); therefore no new blinds could be added at Big Break. It is unknown if DFG would allow more blinds at Sherman Island; more blinds could potentially lead to overcrowding and safety issues.

< *User conflicts associated with increased use.* A future constraint could arise from user conflicts related to increased use of new facilities. User conflicts could occur between *nonmotorized* boaters and motorized boaters in thoroughfares, between anglers and day users or floating campers, and between hunters and boaters as use increases and becomes more diverse. Conflicts between nonmotorized boaters and motorized boaters could arise in sloughs where increased numbers of nonmotorized boaters would travel to the quieter slough and open water edge areas where motorized boaters are less numerous or absent. Whether conflicts would arise likely would depend on traffic levels, time of year, speed of other boaters, and whether motorized boating thoroughfares need to be crossed to reach quieter

boating areas. Conflict between anglers and day users or floating campers could occur if beaches or floating campsites are constructed near prime fishing areas. Day users or campers could be loud and therefore might disrupt anglers or decrease catch rates. Conflicts between hunters and boaters could occur if, as a result of improvements, boating use increases during hunting season. Although this could lead to safety issues, it would require a significantly large increase in boating use in this off-peak season.

< *Recreation conflicts with ecosystem restoration and wildlife.* Restoration can be seen as both an opportunity and a constraint because it benefits activities such as wildlife viewing, hunting, and fishing, but large area restoration could lead to a loss of boating area and space for anglers, especially during tournaments. Open water areas are important to anglers and boaters, and restoration within these areas may be detrimental to these uses.

POTENTIAL APPROACHES

< *Identify appropriate site conditions for specific recreation opportunities.* Overall, several opportunities are possible for enhancing existing and promoting new recreational opportunities within the study area. Facilities where site conditions would determine installment include beaches, picnic areas, docks, signage, floating campsites, floating restrooms, picnic sites, and floating wildlife viewing/picnic platforms. These facilities would require that cost and maintenance demands be taken into consideration to determine feasibility.

< *Provide for garbage disposal and address potential use conflicts with education.* Other considerations in designing facilities should include garbage disposal and wildlife sensitivity. Unless the “pack it in, pack it out” rule can be expected to be strictly adhered to, any new developments, such as beaches, docks, picnic sites, floating campsites, and floating wildlife viewing/picnic platforms, should contain trash receptacles and have regular trash pickup to avoid affecting water quality and creating floating trash. Education and interpretive programs can improve visitor behavior. Development of facilities near restoration sites, such as beaches or wildlife viewing/picnic platforms, should take into consideration effects on wildlife, including the sensitivity of wildlife to noise and human presence. Timing of use and potential seasonal restrictions to protect wildlife during particularly sensitive times, such as nesting, may be needed.

< *Conduct monitoring and surveys to better understand recreational issues and needs.* Specific studies regarding boat traffic, future use, site specific locations of possible facilities, engineering feasibility of facilities, cost of facilities and maintenance, and cost sharing, of facilities and maintenance should be conducted to evaluate proposed alternatives. In addition, surveys regarding the preferences, perceptions, and needs of area recreationists would help identify specific opportunities for enhancements.

< *Identify appropriate sites for specific recreational opportunities.* Although evaluation of specific sites for potential facilities is dependent on design specifics, engineering and cost constraints, and the need for further information on factors such as boat traffic patterns and wildlife needs, some attempt can be made to identify which study sites have the best

potential for certain new facilities. Wildlife viewing/picnic platform locations are best sited at Big Break and Franks Tract (such a platform has been recently built at the EPRPD park shoreline at Big Break); Sherman Island may be too windy for such a facility. Restoration of tidal marsh habitat is possible at all three study sites, as ecosystem restoration elements, and may provide the added benefits of nonpowered boating and wildlife viewing opportunities in conjunction with other recreational enhancements. Floating campsite locations are more suitable for Big Break and Franks Tract than Sherman Island because of strong winds at that site, although wind is an issue at all three sites. Floating campsites at either Big Break or Franks Tract would require careful placement, anchoring, and possibly wind breaks.

- *Identify appropriate levee locations for newly integrated beach opportunities.* At Franks Tract, beaches are possible along new levees at several different locations. Traffic and safety constraints for beaches on levees would need to be further investigated to determine feasibility. Sherman Island and Big Break have not been identified as sites for levee repair or modification to improve water quality. Thus, beach construction opportunities would need to be evaluated purely as recreation enhancements. Once locations of beaches are determined, feasible locations for beach-side picnic areas, docks, and nearby mooring areas could be determined. Floating restroom placement would best be determined in coordination with other improvements, such as mooring areas, beaches, boating channels, and other boating enhancements, which are most likely to be located at Franks Tract.

- *Public stewardship outreach and education.* Develop and fund ongoing programs aimed at engaging the public and private stakeholders in integrated “environmental stewardship” to help ensure the long-term success of potential improvement / restoration efforts.

2.5 HYDRODYNAMIC CHANGES AND ASSOCIATED EFFECTS

Potential site modifications are specifically designed to change the transport of salt in the Franks Tract area. This could alter the range of flood stage elevations, flow velocities, and wind-wave fetch. Increasing flood stage elevation increases the risk of levee failure and/or overtopping. This is a major concern in the Delta because of the potential for water quality deterioration and reduction of water supply, as well as human safety and levee, crop, and other property damage. Decreasing minimum stage elevations may result in adverse effects associated with irrigation pump siphons; however, changes in stage are expected to be minimal. Manipulation of flow velocity could result in additional scouring and levee erosion, as well as sedimentation. Decreasing wind-wave fetch in the large open water of Franks Tract could reduce erosion on levees and other landforms. This section evaluates opportunities, constraints, and potential approaches related to changes in the hydrodynamics in the vicinity of the study area.

OPPORTUNITIES

- *Increased control of flood elevations.* Potential improvements present opportunities for increased manageability of local flows and flood elevations. The three main events that cause higher tides and flooding conditions in the central Delta are high flows from rivers and streams following a major storm or runoff event, lunar high tides in December and January associated with winter solstice, and low atmospheric pressure. Individually and combined, these events often result in flooding in the Delta. Typically, these events can be predicted a few days to weeks before the actual flood event. Because there would be enough lead time, operable gates could be opened to accommodate flood flows.

- *Decrease in fetch and associated wind-wave erosive processes*. Potential improvements that may include levee repairs, setback levee construction, and tidal marsh creation may break-up and reduce wind-wave fetch across the expansive open water of Franks Tracts. Reduced wind-wave fetch could have beneficial effects in reducing associated erosive forces on levees, including those that protect developed areas of Bethel Island.

CONSTRAINTS

- *Potential increases in maximum flood-stage elevations.* The heights of the existing levees in the Delta represent the absolute maximum height that flood elevations would be allowed to reach without flooding adjacent lands. However, as flood elevations increase beyond the existing range, the increased pressure exerted on the levees could cause internal erosion of the levees at their weakest points, such as buried irrigation pipelines, animal borrows, dead trees and roots, and permeable gravel and riprap layers. The prevalence and locations of these weak points are largely unknown. In the case of animal borrows, new weak points are constantly created above the typical high-tide line. Potential site modifications could generally reduce hydrologic connectivity to Franks Tract; thus, water may increase flood stage elevations in the surrounding channels and beyond. Increases in stage are expected to be small and are easily evaluated with numerical models. Consideration must be given to the heights of existing levees and maintaining levee freeboard in nearby areas.

- *Potential decreases in minimum stage elevations.* The minimum stage elevations that must be maintained would be dictated by requirements of irrigation pump siphons, existing and restored habitats, and recreational facilities. Water levels must be kept above the low point of siphons to avoid damage to irrigation pumps in the Delta, including those at nearby Webb Tract, Mandeville Island, Holland Tract, and others (see Exhibit 2.2-2 for a map of agricultural diversion locations). Changes in water stage elevation resulting from potential modifications should be modeled before project implementation and monitored after project construction to clearly understand how potential changes affect minimum stage elevations.

- *Increase in flow velocity and related scour and erosion potential.* Increases in velocity could result in additional scouring and erosion potential, which could damage levees. Particular consideration should be given to levees, inside and outside the study areas, where significant erosion already occurs and the risk of levee failure is greatest. Levees at channel bends are particularly susceptible to erosion caused by scouring. Potential site modifications could have the potential for increasing velocity in the channels surrounding Franks Tract, as well as upstream and downstream channels. The susceptibility of levees along False

River, Old River, Piper Slough, and Sand Mound Slough to erosion should be given particular consideration.

- *Decreases in flow velocity.* Decreases in velocity may result in localized increases in sediment deposition, shoaling, and SAV. The potential site modifications could periodically reduce flow velocities in Franks Tract and may, therefore, increase sedimentation, shoaling, and SAV growth. Effects of increased sedimentation within Franks Tract are discussed in Section 2.4, "Recreation Issues."

POTENTIAL APPROACHES

- *Use of operable gates for flood control*. Operable tidal gates would allow for greater manipulation of the volume and timing of flows in and out of the study areas and, thus, could potentially be used to reduce flooding risk. Modeling could be used to predict the effect of opening and closing gates to minimize the risk of flooding under various scenarios; post-construction monitoring, including collection and evaluation of observed effects, would be instrumental in altering gate operations to achieve desired effects.

- *Analyze potential effects and investigate local levee conditions*. Potential effects on flood stage and water velocities should be modeled and analyzed to determine potential adverse effects. Also, an investigation of levees should be conducted to identify locations where conditions are susceptible to failure. For example, increases in flood elevation in nearby areas may increase flood risk. Increases in flow velocity could result in increased scouring and erosion potential. Although levees are typically designed according to USACE standards for various levels of storm events (e.g., 100-year flood event protection), there is no assurance that the existing levee heights or conditions are adequate to maintain the designed level of protection. Erosion and subsidence, in particular, may have reduced the height and structural integrity of levees.

- *Analyze potential effects on irrigation diverters*. Minimum stage elevations should be maintained above the low point of irrigation intake siphons to avoid damage to irrigation pumps. Potential effects on low water stage elevations should be modeled and analyzed, and an investigation of irrigation intake locations and local critical-stage elevation requirements should be conducted to determine potential adverse effects.

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Table 2-1
Summary Opportunities and Constraints Analysis

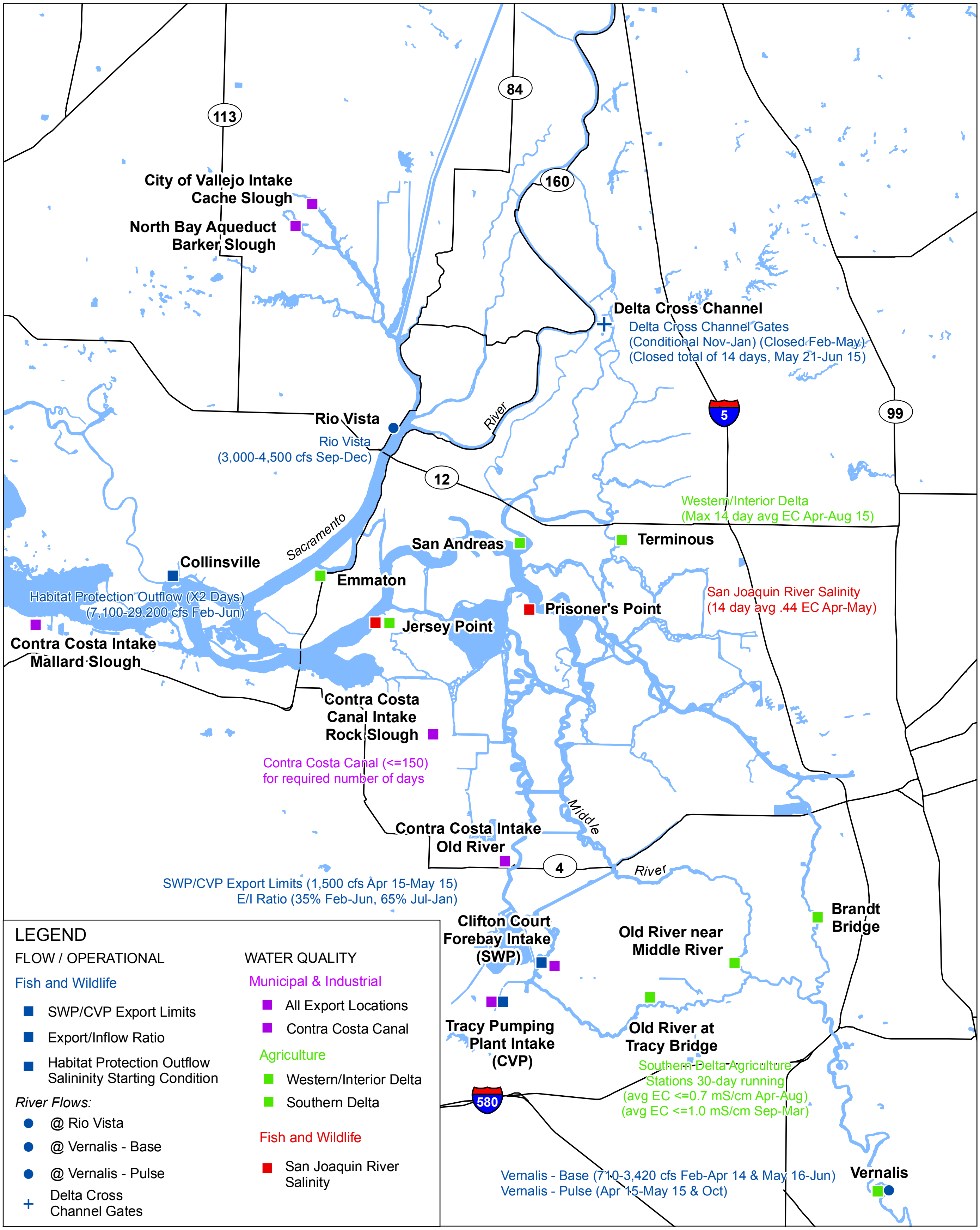
Goals and Objectives	Issues	Opportunities	Constraints	Potential Approaches
Water Quality Improvement – Objectives 1, 2, and 3				
Salinity • Reduce salinity concentrations at central and south Delta export/diversion facilities	• Issues surrounding flooded islands o Location in Delta – salinity gradient o Salt mixing o Salt trapping • High salinities at south Delta export/diversion facilities in summer and fall • Water quality standards • Protection of beneficial uses	• Reduce salinity concentrations at south Delta export/diversion facilities o Achieve municipal benefits o Achieve agricultural benefits • Increase efficiency, flexibility, reliability, and assurance of upstream SWP/CVP reservoir operations to meet multiple use standards and objectives • Increase efficiency of Delta outflows to control X2 • Potential for synergistic benefits associated with other Delta operations	• Potential for adverse changes in residence time and reverse flows in San Joaquin River • Potential adverse changes (increases) in salinity concentrations at other Delta locations • Potential for changes in flow-salinity relationships that could affect SWP/CVP operations and Delta water quality standards • Potential for additional modeling coordination required to develop appropriate CVP/SWP operating assumptions	• Levee reconstruction and/or new levee construction • Incorporate the use of operable gates and locate facilities to optimize benefits and allow for increased water quality management (including adaptive) • Consider safety and flexibility factors into potential element designs
Organic Carbon • Decrease flow of reactive forms of DOC (and associated potential for THM formation in drinking water) to export/diversion facilities • Increase primary production available to western Delta food web for ecological benefits	• Sources o Riverine sources o In-Delta primary production o Delta discharge o Wetland export o Point sources o Surface runoff • Forms • Cycling o Primary production, consumers, decomposition • Potential drinking water contaminant • Important driver to productivity in the food web	• Reduce DOC concentrations at central and south Delta diversion and export facilities • Potential to increase food web productivity in the Delta • Increased understanding of planktonic, food web, and organic carbon related processes	• Increase DOC concentrations at central and south Delta diversion and export facilities • Uncertainties associated with invasive SAV (Egeria) DOC production • Uncertainties in ecosystem response and subsequent carbon processes resulting from potential site modifications • Enriched pore water ejection	• Perform baseline testing and post-implementation monitoring to better understand planktonic, food web, and organic carbon related processes • Incorporate the use of operable gates to allow experimental adaptive management of flows to potentially grow phytoplankton and flush to western Delta • Consider potential increases in DOC production resulting from ecosystem restoration elements • Consider clam grazing effects in planning and implementation
Methylmercury • Limit production of MeHg and subsequent bioaccumulation in food web	• Sources o Natural and anthropogenic • Methylation is key step into food web – bioaccumulation • Rates of methylation are influenced by: o Concentration and form of Hg o Hg bioavailability o Distribution and activity of methylating (i.e., sulfate-reducing) bacteria • Wetland MeHg production	• Improved understanding of MeHg processes is progressing, and relative risks of potential strategies can be better quantified • Potential elements could reduce known MeHg production factors • Diversity of processes provides some assurance of minimal ecosystem change compared to existing conditions • Increased understanding of MeHg production processes	• Existing uncertainties of some MeHg formation factors present institutional challenges • Potential for increased MeHg formation • Enriched pore water ejection	• Integrate MeHg formation consideration into study planning • Perform baseline testing of existing reactive mercury levels to characterize range of representative conditions, and subsequently develop strategies that minimize adverse changes to high-risk areas • Test and use clean fill material for potential elements/features • Prepare and implement a mitigation and monitoring plan

Table 2-1 Summary Opportunities and Constraints Analysis				
Goals and Objectives	**Issues**	**Opportunities**	**Constraints**	**Potential Approaches**
Ecosystem Restoration – Objectives 1, 2, 3, and 4				
Tidal Marsh Habitat • Restore and enhance tidal marsh habitat • Habitat diversification	• Habitat homogeneity at Franks Tract • Dominance of invasive and other nonnative species at flooded islands • Loss of tidal marsh/wetland habitat throughout Delta.	• Increase tidal marsh habitat through restoration • Increase mudflat habitat through restoration • Increase native habitat for special-status and other native fish and wildlife species • Increase habitat diversity • Protect and enlarge existing remnant habitat	• Sites that could be restored through planting alone are limited • Scour and shoreline erosion potential • Limited site accessibility • Potential for increased mosquito production • Competing uses • Invasive species colonization • Constructability constraints o Depth o Subsidence o Material availability o Cost o Sustainability	• Design tidal marsh at appropriate elevations • Use of bioengineering techniques • Apply knowledge from other Delta restoration sites and experiences • Design habitat restoration to interface with adjacent channels vs. flooded island open water • Integrate restoration into other elements o New levees o Riparian scrub • Design tidal marsh into confined/semi-confined areas • Design projects to be self-mitigating
Riparian Scrub Habitat • Restore and enhance riparian scrub habitat • Habitat diversification	• Habitat homogeneity at Franks Tract • Dominance of invasive and other nonnative species at flooded islands • Eroding remnant levees	• Increase riparian scrub habitat through restoration • Increase habitat for special-status species • Increase native habitat for wildlife species • Increase habitat diversity • Protect and enlarge existing remnant habitat	• Scour and shoreline erosion • Limited site accessibility • Levee instability	• Design riparian scrub at appropriate elevations • Integrate restoration into other elements o New levees o Marsh o Beaches
Fisheries • Restore special-status and other native fish species • Maintain recreationally important game fishery	• Special-status species • Recreationally important nonnative fish species • Predation • Migration • Entrainment	• Improve migratory conditions for native fish species • Improve and increase aquatic habitat diversity for native and recreationally important fish species • Reduce fish entrainment at export/diversion facilities	• Changes in native fish concentrations and exposure to predation • Barrier and impediments to migration • Nonnative/native fish and SAV relationships	• Restore native habitats and habitat diversity for native fish species • Design potential gates to operate to have benefit or to minimize adverse effects on migration of native fish species
Invasive and Other Nonnative Species • Control or reduce spread and colonization of invasive and other nonnative species o *Egeria densa* o *Corbicula fluminea*	• Invasive species densities and distribution • Invasive species effects and relationships on/with native and nonnative species • Recreation and navigation effects	• Increase understanding of influences of habitat on susceptibility to invasive aquatic species • Reduce Egeria and Corbicula densities • Reduce Egeria and Corbicula success	• Potential activities resulting in increased Egeria and Corbicula • Invasive species competitive edge • Uncertainties o Ecosystem responses o Distribution movement	• Create conditions not suitable for invasives establishment • Design habitats to give native species an advantage • Physical and chemical control • Dredging • Adaptive management

Table 2-1 Summary Opportunities and Constraints Analysis				
Goals and Objectives	**Issues**	**Opportunities**	**Constraints**	**Potential Approaches**
Recreation – Objectives 1, 2, and 4				
Boating and Access • Maintain and/or improve boating access and navigation	• Maintenance of travel corridors for boats • Recreational activities • Access to marinas and other facilities	• Maintain boating access • Dredging of primary navigation channels	• Construction of permanent barriers in channels and waterways • Construction and operation of tide gates in channels and waterways • Repair and reclamation of remnant levees and levee gaps • Increased growth of SAV • Changes to flow patterns • Costs, permitting and impacts associated with dredging	• Locate gates and barriers away from primary navigation channels and access points • Incorporate navigation locks and/or boat ramps into potential barriers and/or gates • Incorporate recreational facilities into new or repaired levees • Target dredging to areas infested with SAV • Carefully consider potential elements that may increase SAV growth • Implement boater safety and education program
Maintain Open Water • Maintain large open water areas for recreational activities	• SAV growth interferes with navigation • Facility needs	• Dredge boating channels • Add needed facilities	• SAV growth • High costs and temporary results associated with current SAV control methods • Potential changes in hydrology • Potential changes in residence time (nuisance)	• Focus dredging and Egeria control efforts to strategic locations • Integrate mooring areas with other recreational facilities • Provide alternative recreation experience through the creation of increased tidal marsh • Conduct monitoring and surveys to better understand and define recreational issues and needs

Provide Enhanced or New Recreational Opportunities
• Enhance boating, fishing, camping, wind/kite surfing, hunting, and wildlife viewing experiences and overall recreational experience
	• Facility needs
	• Stewardship and education
		• Incorporate recreational and other facilities into other improvement elements
		• Expand facilities to provide for fishing tournaments
		• Enhance opportunities
		  o Wildlife viewing
		  o Wind-/kite-boarding
		  o Hunting
		• Improve and increase
		  o Availability of general visitor facilities
		  o Camping facilities
		  o Day-use facilities
		  o Opportunities for non-motorized boating
		• Enhance educational and interpretational opportunities
		• Public stewardship and education opportunities
			• High capitol and maintenance costs
			• Lack of upland sites
			• Natural elements, erosion, sustainability
			• Integration of policies across political boundaries
			• User conflicts
				• Site suitability analysis for specific opportunities
				• Floating campsites
				• Garbage disposal and education
				• Public stewardship and outreach
				• Conduct monitoring and surveys to better understand and define recreational issues and needs

Table 2-1 Summary Opportunities and Constraints Analysis				
Goals and Objectives	**Issues**	**Opportunities**	**Constraints**	**Potential Approaches**
Hydrodynamic Changes and Associated Effects – Objectives 1, 3, and 4				
Hydrodynamic Changes and Associated Effects • Achieve benefits or maintain existing desirable characteristics related to flood control and hydrology	• Alteration of o Stage elevations o Flow velocities o Wind-wave fetch	• Increased control of flood elevations • Decrease in fetch and associated wind-wave erosive processes	• Potential increases in maximum flood-stage elevations • Potential decreases in minimum stage elevations • Increase in local flow velocity and related scour and erosion potential • Decrease in flow velocity	• Use of operable gates • Analyze potential effects and investigate local levee conditions • Analyze potential effects on irrigation diverters



Source: CALFED Independent Science Board 2002

Delta D-1641 Water Quality Standards Stations and Water Diversion/Export Facilities

EXHIBIT 2.2-1

Flooded Islands Pre-Feasibility Study Report

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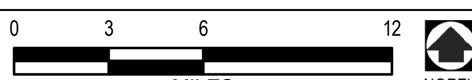

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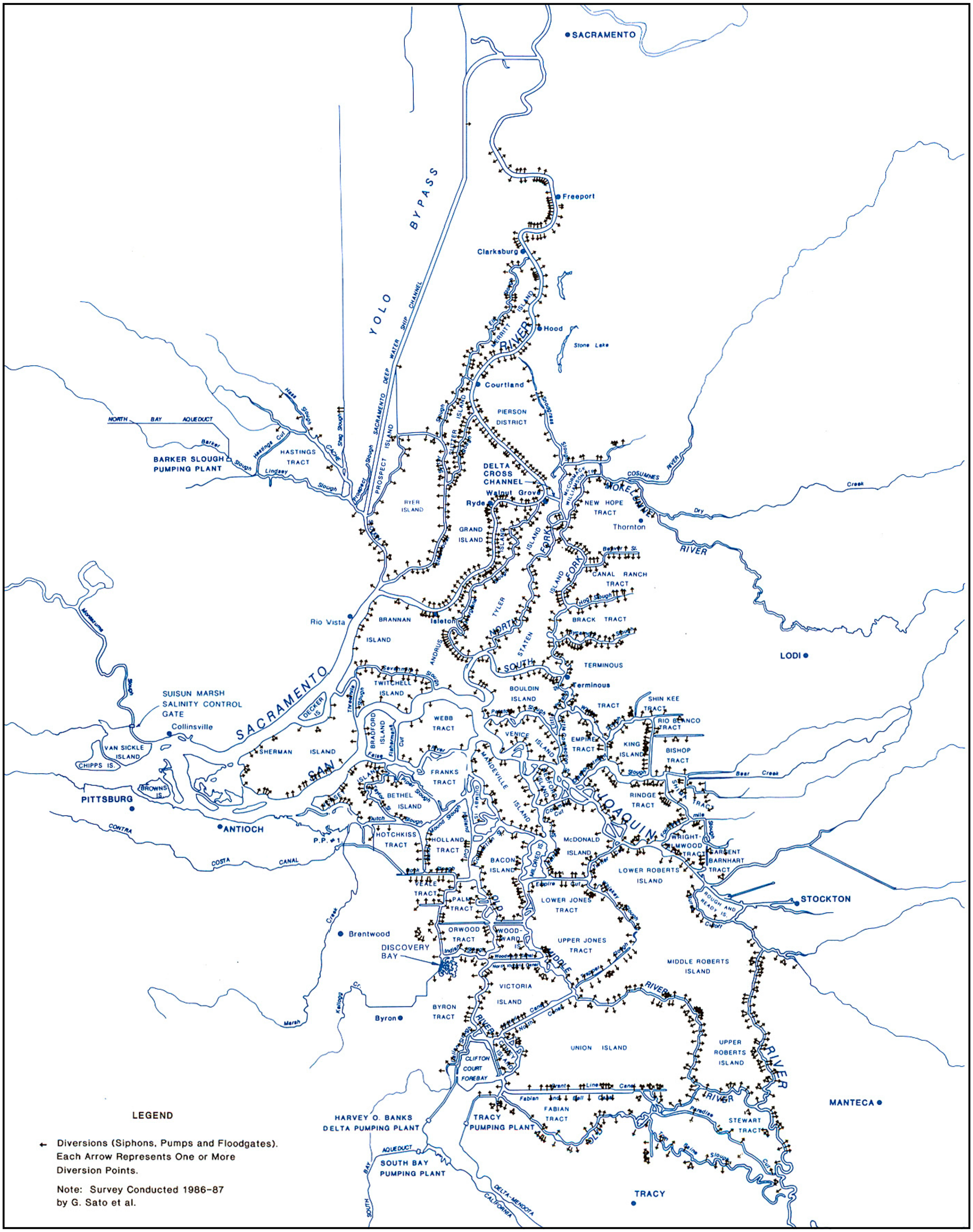

Source: DWR Sacramento-San Joaquin Delta Atlas

EXHIBIT 2.2-2

Irrigation Diversions

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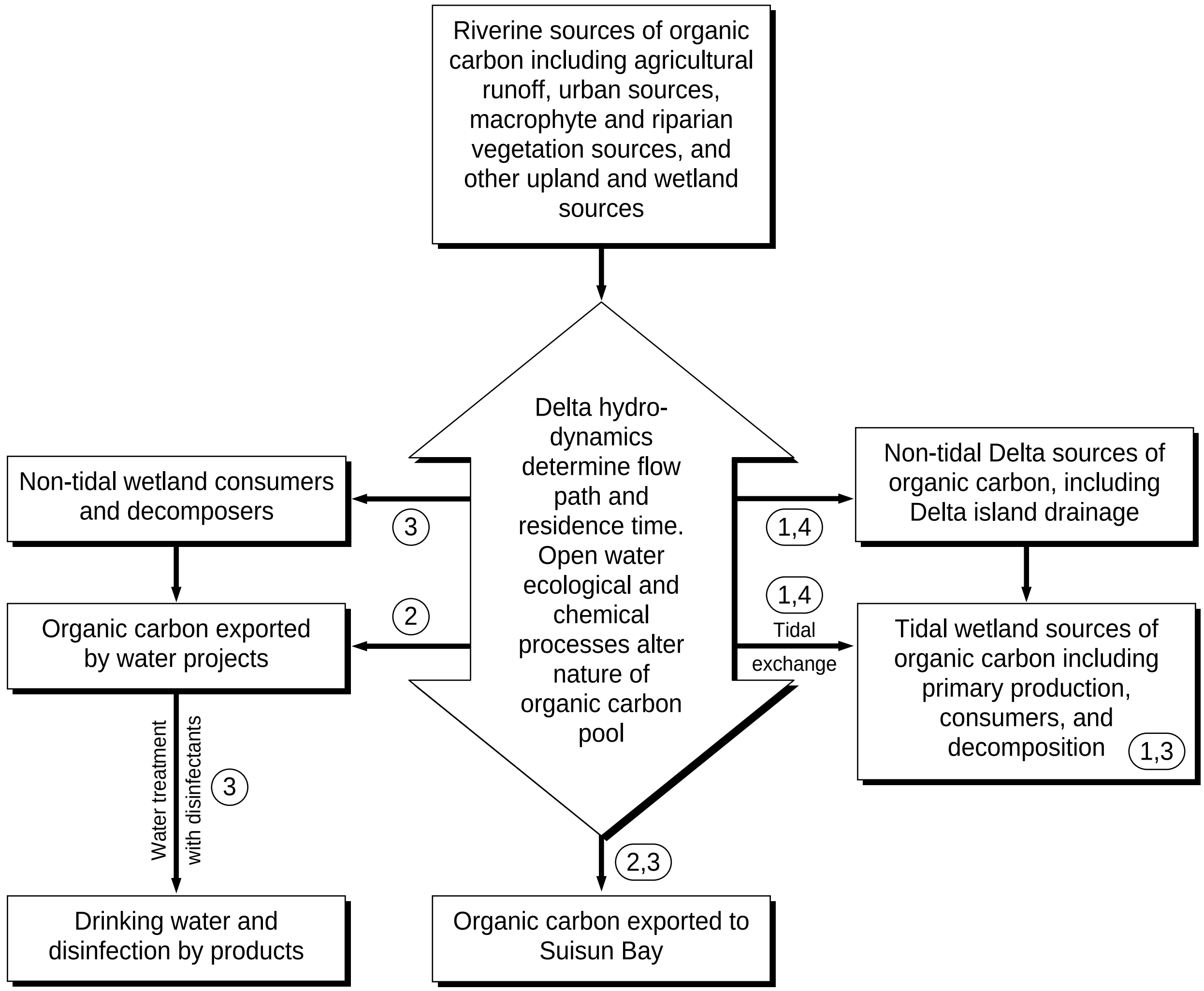
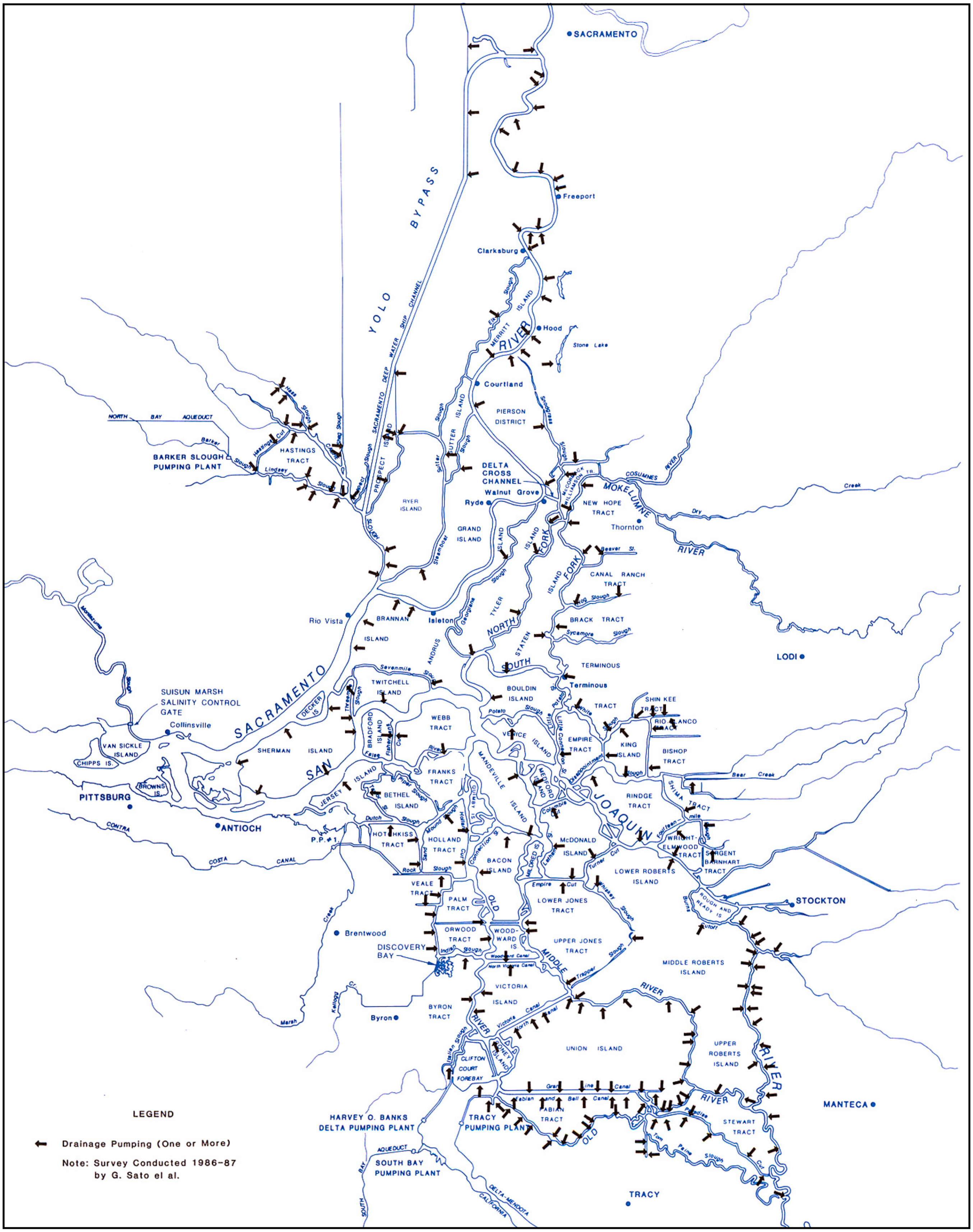


Numbers correspond to the major uncertainties identified in the text: (1) sources of organic carbon, (2) transport processes, (3) quality of organic carbon, (4) management actions. The location of the numbers indicates where a major uncertainty is particularly important in the conceptual model. Addressing these uncertainties is key to understanding and managing the system.

Source: Brown 2003a

Conceptual Model of Organic Carbon Process in the Sacramento-San Joaquin Delta

EXHIBIT 2.2-3



Source: DWR Sacramento-San Joaquin Delta Atlas

Agricultural Drainage Returns

EXHIBIT 2.2-4

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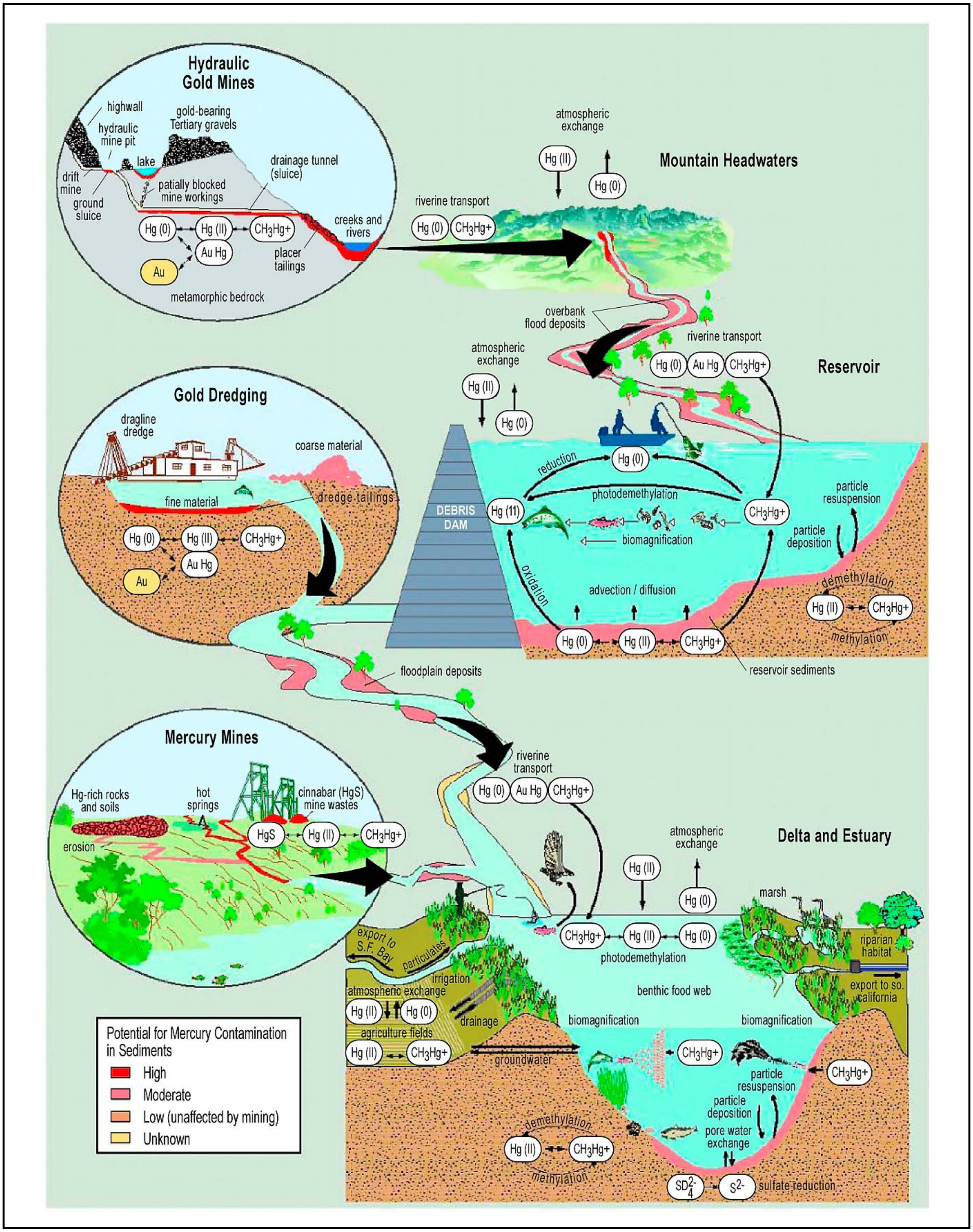
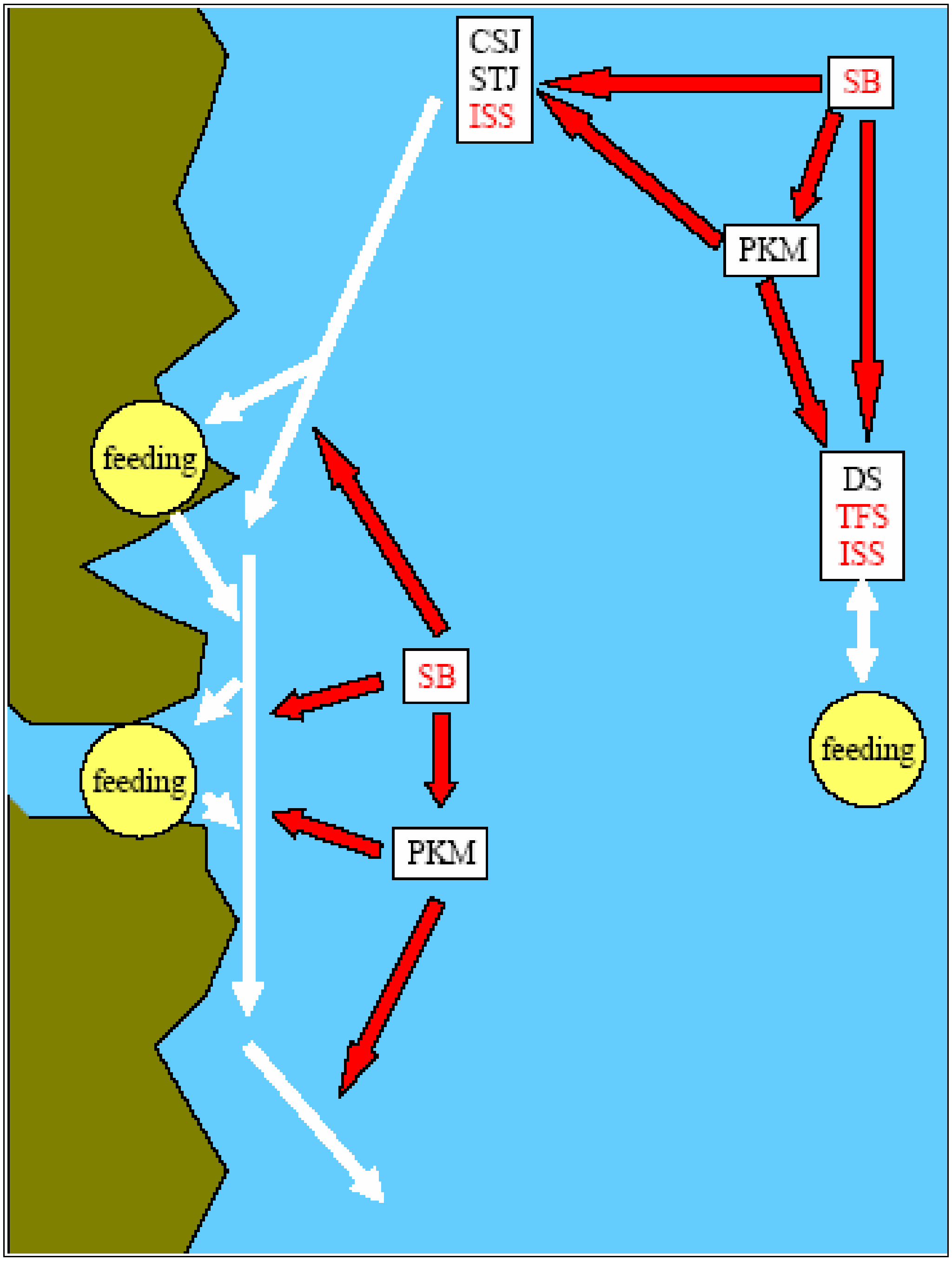


Source: Heim et al. 2003

Conceptual Model of Mercury Processes in the Sacramento-San Joaquin Delta

EXHIBIT 2.2-5

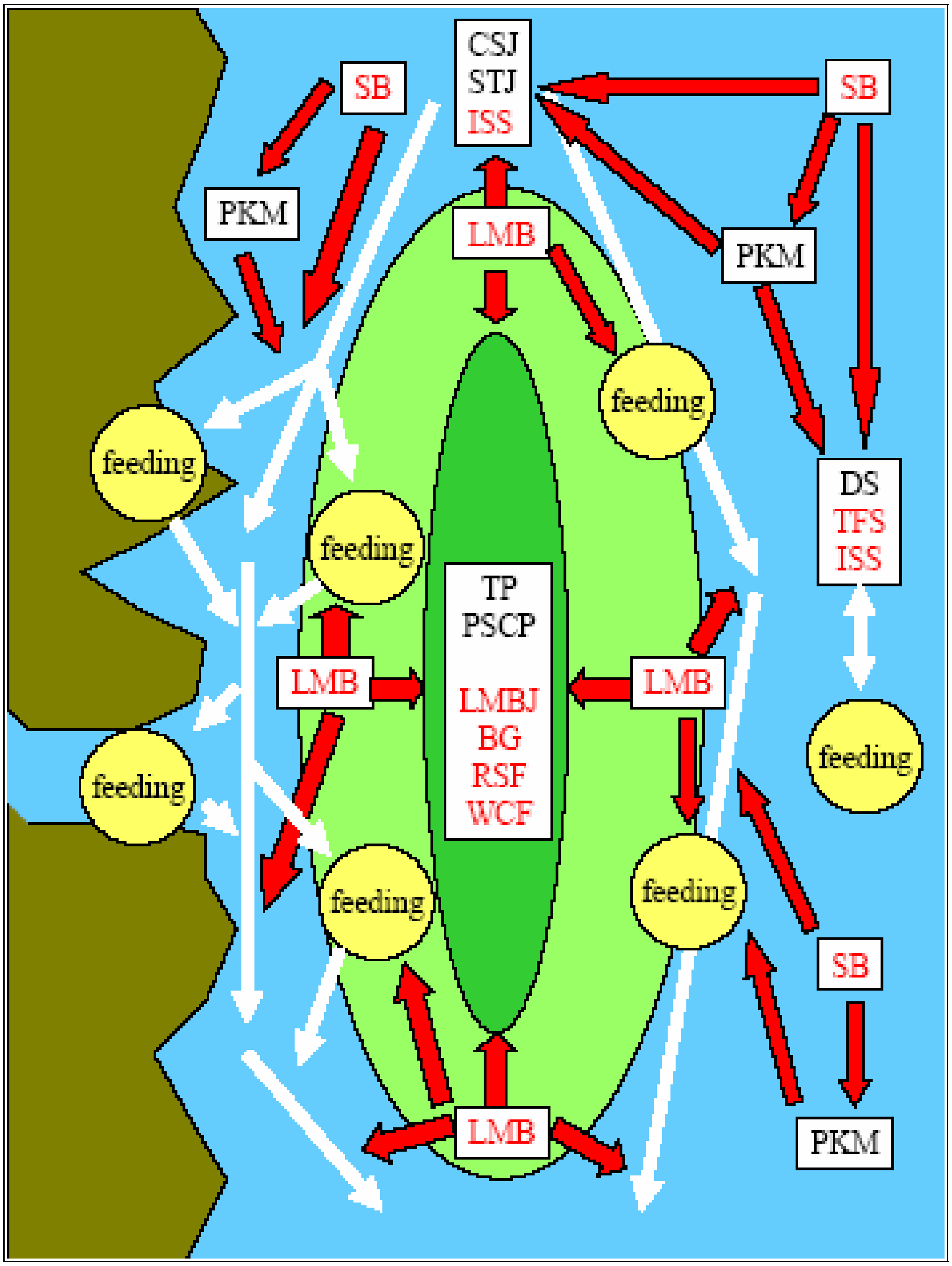


Species codes in red indicate alien fishes. Red arrows indicate piscivory. White arrows indicate prey movements. Yellow "feeding" circles represent feeding activities of prey fishes. Blue indicates open water. Olive green indicates emergent vegetation. The light green oval represents low-density submerged aquatic vegetation and the dark green oval represents dense submerged aquatic vegetation. Species codes: BG–bluegill; CSJ–juvenile chinook salmon; DS–delta smelt; ISS–inland silverside; LMB–adult largemouth bass; LMBJ–juvenile largemouth bass; PKM–adult Sacramento pikeminnow; PSCP–prickly sculpin; RSF–redear sunfish; SB– adult striped bass; STJ–juvenile splittail; TFS–threadfin shad; TP–tule perch; WCF–white catfish.

Source: Brown 2003b

Conceptual Model for Fish Habitat Use in Delta Freshwater Tidal Wetlands without SAV

EXHIBIT 2.3-1



Species codes in red indicate alien fishes. Red arrows indicate piscivory. White arrows indicate prey movements. Yellow "feeding" circles represent feeding activities of prey fishes. Blue indicates open water. Olive green indicates emergent vegetation. The light green oval represents low-density submerged aquatic vegetation and the dark green oval represents dense submerged aquatic vegetation. Species codes: BG–bluegill; CSJ–juvenile chinook salmon; DS–delta smelt; ISS–inland silverside; LMB–adult largemouth bass; LMBJ–juvenile largemouth bass; PKM–adult Sacramento pikeminnow; PSCP–prickly sculpin; RSF–redear sunfish; SB–adult striped bass; STJ–juvenile splittail; TFS–threadfin shad; TP–tule perch; WCF–white catfish.

Source: Brown 2003b

Conceptual Model for Fish Habitat Use in Delta Freshwater Tidal Wetlands with SAV

EXHIBIT 2.3-2

Source: Airphoto USA September 2002

Aerial of Franks Tract Showing Egeria Growth

EXHIBIT 2.3-3

Flooded Islands Pre-Feasibility Study Report

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3 PRELIMINARY ALTERNATIVES DEVELOPMENT AND ANALYSIS

This chapter describes the development and analysis of preliminary alternatives for the Flooded Islands Pre-Feasibility Study. The purpose of the chapter is to describe the methodology used to logically formulate, evaluate, and compare a range of preliminary alternatives. This analysis builds on efforts detailed in the "Conceptual Alternatives Report" and Chapter 2, "Opportunities and Constraints Analysis," and includes the selection and evaluation of potential approaches, options and elements, and the formulation of preliminary alternatives based primarily on water quality (e.g., salinity) modeling exercises.

The preliminary alternative development and analysis began with the identification and evaluation of several potential approaches (generated from Chapter 2) and options for achieving study objectives. Preliminary scenarios were developed first based on a broad range of options for reconfiguring one or more of the three flooded islands to reduce salinity at the south Delta export/diversion facilities based on expert opinion and general principles of hydrodynamics. For ecosystem restoration, a number of site-specific options for restoring tidal marsh or riparian habitat in or around the three flooded islands were identified and evaluated. Land managers and a group of stakeholders from Bethel Island were interviewed to identify recreational objectives and constraints, particularly at the Franks Tract study area. Table 3-1 lists the potential scenarios for advancing study goals.

Table 3-1 **Potential Scenarios for Advancing Study Objectives**
Water Quality < Modify Franks Tract, Lower Sherman Lake, and/or Big Break to alter tidal hydrodynamics to reduce salinity at the CVP, SWP, and CCWD pumps.
Ecosystem Restoration < Create tidal marsh and riparian scrub habitat within flooded islands. < Create tidal marsh habitat on subsided islands adjacent to the flooded islands. < Create avian habitat islands. < Protect existing marsh and island habitat, including that associated with remnant levees from wind-wave erosion. < Manage residence time in flooded islands to increase primary productivity in western Delta (related to water quality).
Recreation < Provide and maintain navigable boatways. < Provide open water areas free of Egeria for boating, fishing, and other water sports. < Maintain circulation and water quality for aesthetics, fishing, and water sports. < Provide beaches with boating access. < Protect the north shore of Bethel Island from wind-wave erosion. < Provide mooring areas for boaters. < Reduce navigation hazards associated with submerged levees particularly at Horseshoe Bend. < Provide bathrooms and other amenities for small watercraft.

3.1 TOOLKIT

Once the potential opportunities for achieving each objective were identified, strategies for achieving each objective were evaluated and a "toolkit" consisting of the preferred actions or approaches (i.e., tools) was developed (see Table 3.1-1). The following section verbally and graphically describes these tools and explains which tools were not selected as preferred tools and why.

Table 3.1-1
Preliminary Alternatives Preferred Toolkit

Water Quality Tools < Construct habitat levees around portions of flooded islands to prevent the exchange of salt between flooded islands and perimeter channels. < Construct tidal gates to control mixing of salt between Franks Tract and perimeter channels.
Ecosystem Restoration Tools < Create tidal marsh in flooded island areas adjacent to deep channels. < Create habitat levees – to 1) provide linear marsh and riparian scrub habitat adjacent to deep channels on the perimeter of flooded islands and to create habitat diversity, and 2) to protect habitat on remnant levees and existing mid-channel islands from wind wave erosion. < Evaluate opportunities to control residence time with tide gates. < Evaluate the potential to elevate the peat bottom of Little Franks Tract to restore tidal marsh.
Recreation Tools < Construct navigation locks to allow boat movement wherever gates are constructed. < Locate and develop beaches in areas with low currents and wave action. < Dredge sandy areas to a depth of 12 feet or more to inhibit Egeria colonization and create topographic diversity. < Dredge sandy areas along boating ways to a depth of 12 feet to facilitate navigation and inhibit Egeria. < Establish mooring areas near beaches in areas with low wind and waves during summer months. < Control Egeria, if possible, to maintain open water areas for recreation.

3.1.1 WATER QUALITY IMPROVEMENT TOOLKIT[1]

Three primary tools for controlling movement of water and salt in the Delta were developed: (1) reconstruction of levees around flooded islands; (2) construction of permanent or seasonal barriers in Delta channels; and (3) construction of tidal gates across Delta channels or in levee breaches. These tools, described in greater detail below, could be used separately or in combination to reduce transport of salt from the western Delta to central and south Delta export/diversion facilities.

[1] The term "water quality" primarily refers to salinity (measured as EC) except where otherwise expressed.

LEVEES

Levees affect salinity in the Delta by altering the path of tidal flows and thus physically changing hydrodynamics. An appropriately placed levee may redirect tidal flows, eliminate cutoffs, and increase the distance between the Bay and south Delta export/diversion facilities.

In addition to changing local transport characteristics, levees affect other aspects of the system. Levees create barriers that may block fish passage and boating access, decrease circulation, and increase residence time. Although levees redirect tidal flows, they also have the potential to change localized water velocities and associated sheer stress. Such changes could result in adverse effects on other parts of the levee system, potentially increasing scour, or otherwise resulting in unintended consequences elsewhere.

Levees constructed to limit tidal exchange differ from levees constructed to protect Delta islands from flooding. Flood protection levees rise several feet above a determined maximum flood stage and must withstand constant pressure from channels, sloughs, and cuts. Levees that redirect tidal flows need not rise above the water surface, can be more porous, and are buoyed by water on both sides. Because remnant levees are unstable and provide habitat benefits, setback levees that are on the island side of the remnant levees are being proposed. The necessary stability berms could be incidental opportunity sites to create tidal habitat or recreational beaches.

PERMANENT OR SEASONAL BARRIERS

Permanent or seasonal barriers serve to block salt water. The barriers could be constructed from rock placed in and built across channels or from concrete and flashboards. Seasonal rock barriers may be removed when conditions do not require their presence, as is done at several locations in the south Delta.

Permanent or seasonal barriers block tidal flows and associated salinity intrusion, but they can create residence time problems, prevent boat passage, and are operationally inflexible.

OPERABLE GATES

The operable gates identified in this toolkit would be similar to the Suisun Marsh Salinity Control Project, Montezuma Slough structure. The gates would be operable on tidal cycles and would also permit boat passage when open or with navigation locks. The operable gates are an expensive element that requires maintenance and operation; however, these structures offer the greatest operational flexibility and adaptive management opportunities.

3.1.2 ECOSYSTEM RESTORATION TOOLKIT

There are a wide range of potential methods to advance ecosystem restoration objectives and numerous tools for implementing each opportunity. This section describes a variety of tools for pursuing tidal marsh habitat restoration, riparian scrub habitat restoration, and enhanced primary productivity.

TIDAL MARSH RESTORATION

Filling Flooded Islands with Dredged Material to Create Tidal Marsh

The most obvious method for converting areas of shallow water to tidal marsh is to fill areas of flooded islands to create intertidal habitat. Donlan Island on the southwestern edge of Lower Sherman Lake is an example of tidal marsh habitat created by deposition of dredged materials. The main constraint of this method is the availability of suitable fill material to restore subsided areas. Fill material can be imported from off-site dredged disposal areas or dredged on-site from the shallow flooded island areas. Primary restoration sites should also be surrounded or confined by a relatively intact levee system, such as Little Franks Tract in order to minimize the quantity of required material.

Elevating Peat Substrate on Flooded Islands to Create Tidal Marsh

It may be possible to elevate the peat bottoms of flooded islands to sea level by injecting a clean slurry underneath the top layer of peat. The potential for this technique was recently discovered at the Montezuma wetlands restoration site in Suisun Bay. The owners of the Montezuma site injected a muddy slurry underneath the peat bottom causing approximately 16 acres of peat to rise up to sea level. Unfortunately, this method is not yet sufficiently understood or tested to recommend it for implementation. In the future, this method would probably only be prudent on smaller flooded islands that are surrounded by a relatively intact levee system, such as Little Franks Tract. Attempting this on large flooded islands could dislodge large areas of peat that could then create water quality impacts and be susceptible to movement, threatening to clog Delta channels. If studies conclude that it is feasible to restore marsh plain elevations with this method, it would obviate the need for large amounts of fill material, thereby eliminating the main constraint to tidal marsh restoration on flooded islands. This method is also significantly less expensive than using dredged material to create tidal marsh habitat. For these reasons, it is recommended that further investigation of this method be conducted in the next phase of this study.

Restoring Subsided Islands

Restoring subsided and unflooded Delta islands to sea level is another option for restoring tidal marsh in the Delta. Some of these opportunities have been previously evaluated in DWR studies (DWR 2002, NHC 2003). The most promising opportunities for restoring subsided islands were considered based on the following reasoning:

1. Some of the most promising sites are adjacent to flooded islands.
2. Restoring subsided islands may have less regulatory hurdles than filling flooded island areas to restore marsh.
3. Restoring subsided islands is a competing demand for the limited amount of upland fill material available to restore tidal marsh in the Delta.

4. Restoring subsided islands to sea level could reduce the potential for levee failure and subsequent island inundation, which could create new flooded islands and associated water quality impacts.

A number of short- and long-term strategies for rebuilding subsided islands have been previously analyzed (DWR 2002, NHC 2003). For the purposes of this report, only short-term strategies for quickly building subsided lands to sea level to support tidal marsh were considered. These include use of upland fill material and rice-straw bales in combination with construction of new cross levees to separate on-island restoration sites from the remainder of the subsided island.

Restoration of deeply subsided areas, however, has not been sufficiently tested for large-scale implementation. Furthermore, the impacts of expanding the tidal prism by creating new areas of tidal marsh on subsided islands have not been analyzed. It is possible that expanding the tidal prism could cause changes in Delta hydrodynamics that would conflict with water quality objectives. Lastly, it is evident that there is not enough fill material to restore the most promising flooded islands sites, as well as the subsided island sites. For these reasons, restoration of subsided islands has not been included in the toolkit of preferred strategies for ecosystem restoration.

Construct Habitat Levees

Wetland and riparian habitat on the remnant levee berms surrounding flooded islands is a significant portion of the vegetated tidal wetland habitat remaining in the Delta. These areas not only provide habitat for a variety of plants and animals, but also buffer the effects of wind-waves on leeward island levees. It is evident from field visits, anecdotal accounts of local boaters, and analysis of historical maps, that these areas are rapidly disappearing because of wind wave erosion. Constructing levees, wave walls, or other structures on their windward side to prevent further erosion may protect these areas. The study team has designed habitat levees that could be constructed on the windward side of remnant levees to both protect existing habitat and add new riparian and marsh habitat that will not be easily eroded by wind waves. Exhibits 3.1-1 through 3.1-5 are “typical” preliminary engineering cross sections for different levee types. Exhibits 3.1-6 through 3.1-14 are “typical” plan view and cross sections illustrating existing conditions and proposed habitat levees. The rationale for devising the cross section and elevations of the setback levees and pocket beaches / habitat areas was based on water levels, geotechnical parameters and wave climate in the area.

Levee Crest Elevation

Water levels in Franks Tract are influenced by tides, winds, surface runoff, and river flows, with tides being the predominant forcing function. On an annual basis, the MHHW elevation in the SF Bay Delta region is exceeded generally only about 5% of the time (i.e., 95% of the time in a given year, water levels are below this elevation). River stage influence in the Delta during winter increases this annual exceedance by about 1% to 2%.

The minimum crest elevation of the new setback levees shown on Exhibits 3.1-1 through 3.1-4 were set at 1 foot above Mean Higher High Water (MHHW = 3 feet above NGVD 1929, which is the project vertical datum). Setting the minimum elevation of the levee crest to 1 foot above MHHW (i.e., +4 ft elevation) essentially eliminates tidal waters from False River going over the top of the new levee except during very infrequent elevated tides in the winter, or when river stage is higher than +4 feet. It should be noted that the levee is not a watertight structure, so mixing will occur both through the levee as well as around the levee ends but at a much reduced rate compared to the no setback levee condition.

The +4 ft elevation was used for the rock dike levees with habitat elements on both sides of the levee, so that vegetation would be sustained over the dike. Where a concrete wall was used in the levee, the top of wall was set at +6 ft elevation (3 feet above MHHW), so that the predominant waves would not scour out the leeward side of the wall. Where a recreational beach element is envisioned (see below, either side of the new levee or at the pocket beach), the crest of the levee was set at +6 ft elevation to allow for public use of the beach, and to prevent sand from being eroded through or over the levee, as well as from the leeward side of the dike/wall.

Levee Width

The soft peat soils within Franks Tract imply that any net increase in overburden pressure, such as with new fill associated with a setback levee or fill for habitat, would have to occur slowly (to allow the peat to consolidate rather than fail) and would have to be spread over a large footprint area to prevent slope failure. The cross sections (see Exhibits 3.1-1 through 3.1-4) show the footprint of sand fill for the levee, which varies from 160 feet to 190 feet for the setback levee with no recreation beach element (Exhibit 3.1-1) and up to 250 feet wide for the levees with recreational beach elements (Exhibits 3.1-2 through 3.1-4). The top of sand fill is just below MLLW to minimize the net overburden pressure (keep the fill buoyant), except for the beach concepts where it slopes up from -0.5 feet to +4 feet elevation at an 8H:1V slope.

Beach Orientation

Typically, the vertical zone of wave energy influence in a water column extends from some distance above Still Water Level (SWL, which depends on tides) to some distance below SWL. The distance above and below SWL depends on wave height and wave period. The larger the wave, the greater the vertical zone of influence. Also, stable beaches are oriented perpendicular to the direction of predominant incident waves. With this orientation, sand moves up and down the slope depending on wave energy, while maintaining a long-term average slope. If the predominant waves come in at some angle to the beach orientation, sand moves along the beach (longshore transport) and it ultimately recedes.

In the Franks Tract area, winds are out of the west through northwest directions about 70 percent of the time during the spring, summer and fall seasons. During the winter, storms produce infrequent but high speed winds from the north and southeast directions. The orientation and limits of the pocket beaches presented below in Section 4.3 is based on wave analysis and longshore transport directions estimated by M&N (M&N 1990, M&N 2002). Beaches in other areas will have a lower likelihood of survival over the long-term.

Isolated islands in the middle of Franks Tract (either beaches or for avian habitat [see below]) will be exposed to waves from all directions, and can be constructed with very coarse fill as a cap. But over the long-term, these islands are expected to require maintenance.

Habitat & Beach Slopes

Waves break as they approach a beach and dissipate most of their energy on the beach. Typical sandy beach slopes vary from 6H:1V to 10H:1V depending on wave energy and grain size of the beach material. Steeper slopes can be sustained in lower wave energy areas or if the material is coarse. For the wave regime within Franks Tract and assuming medium sand as import fill (d50 of approx 0.2 mm) an average slope of 8H:1V was estimated to be stable over the long term. Near the elevation of low and high tides, the slope may be steeper depending on wave activity at certain times of the year. This is normal for a beach in dynamic equilibrium which changes intra-year with season, as well as inter-year with episodic storms, but over the long term it stays at about the same slope and at the same location.

The top of sand fill for the habitat areas on either side of the setback levee (see Exhibits 3.1-1 through 3.1-4) is shown at -0.5 ft elevation, ultimately "day-lighting" at a 4H:1V slope to meet the existing bottom within Franks Tract on one side, and the approximate -3 feet contour on the remnant levee side. For the recreational beach elements, the top of sand fill slopes up at an 8H:1V slope through the inter-tidal area to an elevation of +4 feet. For both elements, the sand fill is expected to be dynamically stable over the long-term. Storms will have local effects (scour in un-vegetated areas and scarps on the beaches) which will "smear" out over the summer months. Unusually strong storms from an infrequent direction may erode 1 or more of the pocket beaches shown, which may have to be maintained to bring back desired elevations. However, this is expected to be an infrequent, episodic occurrence.

RIPARIAN SCRUB AND AVIAN HABITAT ISLANDS

Creation of riparian scrub associated with habitat levees and relatively small wetland islands could provide significant benefits for avian, herptofauna, and plant species. It is assumed that restoration of dentridic tidal marsh to benefit native fish requires relatively large patches to make a substantial effect; however, much smaller riparian scrub and wetland islands could have benefits for a variety of other species.

Creation of new habitat islands requires large amounts of fill material for a relatively small area of island and is therefore a relatively expensive habitat restoration option. Large foundations of mineral soil to minimize compaction of underlying peat combined with gentle slopes require large amounts of fill material. Small islands are also very vulnerable to wind wave erosion from multiple directions. Protection of existing islands by constructing habitat levees is a more cost effective and sustainable way of providing avian habitat islands for the foreseeable future. Therefore, construction of avian habitat islands is not included as a preferred strategy in our ecosystem restoration toolkit. Creation of riparian scrub associated with habitat levees, however, is included in the toolkit.

ENHANCING PRIMARY PRODUCTIVITY

While studies have shown that light penetration is a primary limiting factor to phytoplankton production in and sinking phytoplankton are probably more prone to light limitation in stratified water columns than to limitation by cooler temperatures the Delta (Jassby et al. 2002), the geometry, hyrodynamics, and benthic community (i.e., Corbicula grazing) of flooded islands also influence the rate of net primary productivity in the form of phytoplankton (Lucas et al. 2002). It may be possible to alter the flooded islands geometry with the intent of changing the transport characteristics to increase primary productivity and thereby increase the energy available at the base of the food web. Changes in the configuration and hydrodynamics of flooded islands could also increase dissolved organic carbon (DOC) concentrations, a byproduct of primary productivity, at drinking water export/diversion facilities in the south Delta.

The objective of this ecosystem restoration tool is to increase the export of phytoplankton from the flooded islands to the low salinity zone for consumption by zooplankton, while minimizing the transport of DOC to the water export/diversion facilities in the central and southern Delta. Decreased ecosystem productivity has been suggested as a contributing factor in the declines of invertebrates and fishes of concern in the estuary (Brown 2003a and b). Because the science of the processes that control net phytoplankton production and export is not fully developed (Lucas et al. 2002), prudent pursuit of this objective requires a controlled adaptive management approach whereby various approaches are implemented in an experimental context. Furthermore, because increasing residence time could result in noxious algae blooms, increased water temperature, or a reduction in dissolved oxygen (DO) levels, it is essential to implement these measures in a manner that allows control and management of residence time.

It may be possible to increase phytoplankton biomass in the western Delta by temporarily increasing residence time in the flooded islands and then preferentially releasing phytoplankton rich water on ebb tides. By installing operable tidal gates on the western edge of Franks Tract and/or False River, it may be possible to control residence time within Franks Tract for an appropriate period of time to encourage a phytoplankton bloom then release the phytoplankton rich water on an ebb tide for transport to the western Delta. Operable gates are necessary to control residence times in Franks Tract so that nuisance algal blooms can be avoided. The gates could be kept open most of the time to control Egeria by maintaining relatively high water velocities within Franks Tract. Moreover, Corbicula biomass could possibly be kept at relatively low levels by “growing” phytoplankton for short periods of time. Because it would be experimental and expensive to construct gates for the untested purpose of enhancing phytoplankton growth, this would only be considered in combination with gates constructed primarily to achieve salinity related water quality objectives.

It may be possible to further increase phytoplankton production by connecting Little Franks Tract to Franks Tract, rebuilding the north and west levees of Franks Tract, and directing tidal flows into and out of Franks Tract via little Franks Tract. This scenario appears to have the best opportunity for growing carbon (phytoplankton) because Little Franks Tract is narrow and is oriented normal to the prevailing winds that would reduce wind wave mixing and create the opportunity for temperature stratification. Temperature stratification can increase phytoplankton production by maintaining phytoplankton in the photic zone and by reducing benthic grazing (Lucas et al. 2002).

3.1.3 BIOENGINEERING TECHNIQUES

A number of bioengineering techniques are discussed in this section for potential use in protecting remnant levees, in-channel islands, and created setback levees from shoreline erosion.

In-channel islands provide a valuable resource by acting as buffers to protect flood control levees from erosion; by providing unique habitat for special-status fish, birds, reptiles, and amphibians away from on-shore predators; and by enhancing aesthetic and recreational opportunities. Several erosion control treatments have proven effective in reducing wave height and energy, and in minimizing erosive forces from tidal and fluvial flows on in-channel islands in the Delta. One project studying these treatments is a bioengineering demonstration project funded by CALFED (Delta In-channel Island Workgroup-DCI 2004). This project was initiated because of concerns about well-documented historic and ongoing losses of in-channel islands. These losses have been shown to be caused by accelerated erosion from fluvial and tidal currents, boat wakes, and wind-wave fetch.

Ten bioengineering design structures were installed in 2001 on three in-channel islands to test the hypotheses that hydrodynamic forces could be dissipated by the installation of these structures, and that shorelines of in-channel islands could be conserved and/or accreted through the use of these biotechnical treatments. Several structures or treatments were studied, including:

< brush walls,
< large log wave breakers,
< small log wave breakers,
< rootwad wave breakers,
< large anchored rootwads,
< peaked stone dikes,
< floating log boom,
< floating log planter,
< mulch pillows, and
< ballast buckets.

The floating log boom and the 1-gallon ballast bucket planters proved ineffective or infeasible and were replaced with other treatments. The other treatments proved to be more sustainable and effective in reducing boat wake heights by 35% to 64% and in reducing wake energy by 57% to 87% (Swanson Hydrology and Geomorphology 2003). Shoreline stability monitoring results showed increases of tule growth behind structures from virtually no cover before treatment to 30% cover after 1 year and 90% cover by the third year. Brush walls, anchored rootwads, and mulch pillows proved the most useful. The other treatments tested for the DCI project are not recommended for consideration as they were less effective and proved difficult and costly to install and maintain.

Brush walls were the most effective treatment, reducing wave heights by 64% and wave energy by 87%. Brush walls consist of material such as discarded Christmas trees packed between two rows of 4-inch wooden posts in a linear arrangement at intertidal depths. Tules are then planted in the backwater between the wall and the shoreline. The second most effective treatment consists of rows of large anchored rootwads, which decrease wave height and energy by 41% and 65%, respectively. Rootwads also provide "large woody debris" habitat for fish and aquatic organisms and special-status plants (some of those installed in 2001 were colonized by *Mason's lilaeopsis*). Anchored rootwads consist of eucalyptus tree stumps and roots installed as breakwaters at intertidal depths. The roots are placed facing away from the shoreline toward the prevailing wave direction, and the rootwads are secured with buried cement, deadman anchors, and galvanized cables. Mulch pillows provide a substrate for preestablishment of tule plantings, and protection from erosive forces. They consist of tules rooted in straw mulch wrapped in burlap or jute. They are secured with wooden stakes to the peat substrate behind brush walls or rootwads at appropriate depths in the intertidal range.

3.1.4 Recreational Improvements

Facilities Associated with Operable Gates and Barriers

Operable tidal gates, which could be constructed to improve water quality, could also provide opportunities for recreation facility enhancements. Locks for boat passage would be a necessity for tidal gates installed in the well-traveled sloughs in and near the study sites. With the expectation that locks would require boaters to queue up and wait to pass through the lock, the opportunity presents itself to include facilities near the locks for use by boaters. Basic facilities associated with locks could include floating courtesy docks and nearby picnic sites and restrooms. More substantial amenities might include a small store selling bait and fishing supplies, snacks and beverages, and boating provisions; a pump-out station; and/or a gas station.

Exhibit 3.1-15 illustrates a typical tidal gate with lock. This gate provides a large lock, approximately 20 × 70 feet for several recreational boats to pass through at once. In the interests of safety and of providing efficient traffic flow, no additional recreational facilities are recommended immediately adjacent to the gates or lock.

Exhibit 3.1-16 illustrates an operable gate with lock with recreational facilities to the east. This theoretical location for additional recreational facilities is far enough from the gates and lock to provide safe shoreline access. Several small docks provide shoreline access for boaters already on the water as well as refueling opportunities. A two-lane boat ramp provides launching access. A building on the levee may house a store, restrooms, and could also serve as a boat rental office. If the facilities are sited on an island or levee that is only accessible by boat, no boat ramp, boat rental, or parking lot would be needed.

BEACHES

Recreational features could also be incorporated into levee setback areas. Currently, there are only a few existing beach and boat mooring sites. These are very popular with boaters during the summer peak boating period. Setback levees along sloughs and on the inside of the flooded islands may be constructed with new beach areas. These sites might also feature additional amenities, such as landing docks, mooring buoys, floating restrooms, and beach picnic sites.

Exhibit 3.1-17 illustrates a large mooring area adjacent to a constructed beach. The top and opposite side of the levee would be constructed as riparian and tidal marsh habitat, respectively. This area would only be accessible by boat. The mooring area might require dredging and Egeria removal to maintain necessary depth and boat access. Restrooms and trash cans on shore should be provided and maintained.

CAMPGROUNDS

Another recreation amenity that could be added to an alternative site is a camping facility. Two types of camping facilities are discussed: floating campsites, which would provide an on-water camping experience, and boat-in campsites, which would offer a land-based, boating-access-only camping opportunity.

Exhibit 3.1-18 illustrates a floating campground with three types of floating campsites. Placing floating campsites together would be more efficient for monitoring and maintenance, such as emptying of restrooms and removal of Egeria. A more remote experience could be provided if campsites were placed in separate locations rather than a cluster as shown. However, this would require more travel time for monitoring and maintenance activities.

The two-story floating campsite to the far left (Exhibit 3.1-18) has a vault toilet, picnic table, and barbeque grill. A staircase provides access to the second story. The first story is effectively shaded by the second story floor, whereas sun bathers can use the second story. The upper floor also provides a vantage point that lower elevations do not provide.

The center floating campsite (Exhibit 3.1-18) is designed for windier locations, with one or more sides enclosed. However, substantial anchoring may be required to prevent drifting. Windsurfers may be interested in this type of on-the-water camping. A vault toilet, picnic table, and barbeque grill would also be provided.

The floating campsite illustrated on the far right (Exhibit 3.1-18) would be open on all sides and provide only a platform, roof, and vault toilet. A wave wall shown in the foreground provides erosion protection for the levee and would also create calmer waters for docked and moored boats.

3.2 SITE SELECTION METHOD FOR APPLICATION OF THE WATER QUALITY TOOLKIT

The preferred strategies identified in the water quality toolkit could be implemented in a number of different locations throughout the study areas. The following section describes the site selection method for application of the water quality toolkit elements for achieving water quality-related objectives. An overview of the RMA Delta model, the primary mechanism used in site selection application of the water quality toolkit, is also provided.

3.2.1 RMA DELTA MODEL OVERVIEW

RMA developed and calibrated a detailed numerical model of Franks Tract and the Delta to evaluate changes on salinity, stage, and velocity (scour), and residence time of the various alternatives (see Model Calibration Report and Alternatives Modeling Report [RMA 2005] for additional detail and information). The primary modeling objective was to quantify water quality benefits of preliminary alternatives, mainly salinity reduction at the south Delta export/diversion facilities. A secondary objective was to determine potential adverse effects such as reduced circulation (residence time), increased peak stage during flood flows and high tidal conditions, low south Delta stage during summertime export/diversion pumping conditions, and change in channel velocities. The full numerical model analysis is described and presented in detail in the report, "Alternatives Modeling Report," (RMA 2005).

The RMA model uses the finite element method to simulate the Delta hydrodynamics and water quality. The model encompasses Suisun Bay with a seaward boundary condition at Martinez, and all the significant rivers and channels of the Delta system. The RMA Delta model employs two-dimensional depth average elements to represent the large open water areas of the system, such as Suisun Bay and Franks Tract, as well as the major channels and confluences of the Sacramento and San Joaquin Rivers. Other channels of the Delta are represented by one-dimensional channel elements. In performing the model simulations, tidal stage and electrical conductivity (EC) are imposed at the Martinez boundary location. Simulations also include all of the Delta rim flows, Delta island consumptive use, exports flows, South Delta barrier operations, operation of the Delta Cross Channel and the Suisun Marsh Salinity Control Gate, and other minor structures found in the Delta.

Because the RMA Delta model represents Franks Tract and the surrounding channels in two dimensions, it is able to better represent the complex flow and salinity patterns observed in the central Delta than existing one-dimensional Delta models. Furthermore, several of the alternatives include partial restoration and reconfiguration of the Franks Tract levees, which would not be possible to directly represent using one-dimensional models.

The salinity analysis was performed using the surrogate measure of EC. The analysis used the historical tide, river flows, exports, agriculture diversions and returns, and Delta gates and barriers operations from April 10 to December 31, 2002. The water year 2002 is classified as a dry year. Salinity transport in the Delta is a function of net flows and tidal mixing. Salinity impacts at the export locations are the result of these short time scale processes integrated over weeks and months. The objective of the hydrodynamic and water quality modeling exercise has been to accurately represent the flow and mixing processes at the tidal time scale so that reliable predictions can be made regarding the changes in salinity associated with proposed alternatives. 2002 is an ideal year for detailed calibration and initial alternative analysis due to the availability of extensive monitoring data collected by the USGS as part of a special study of the Franks Tract region. While final evaluation of the water quality impacts for the eventual preferred alternative should consider performance of the alternative under a variety of water year types, the study calibration and alternative modeling has focused on the 2002 water year.

Several alternatives included operable gates or seasonal channel barriers. These structures were open to all flow in the alternative analysis until June 1 (June 10 for the False River and Sand Mound Slough gates in the East Levee and Gates Alternative) the time that the higher EC waters approached the western end of False River at the San Joaquin River. The gates and seasonal barriers were operating or in place until December 31, 2002. Due to time constraints, minimal effort was expended to optimize gate operation for salinity reduction or other goals. Test simulations indicated a potential for further south Delta salinity reduction with optimized operation of the gated alternatives.

The 2002 simulation period encompasses the extensive flow, temperature, and EC monitoring program conducted in and around Franks Tract by the U.S. Geological Survey from April to August, 2002 (Cuetara et al., In press). These data were used the refine the calibration of the RMA Delta model. The RMA Delta model and model calibration are described in detail in the report, “RMA Delta Model Calibration, Flooded Island Feasibility Study—April 2005.” The calibration study showed that the RMA Delta Model was very good at reproducing observed stage and flow in the Delta. The model also reproduced observed EC in the western Delta and western Franks Tract, but somewhat underestimated the transport of EC through Franks Tract. As a result, model EC was slightly low (10–15%) for the Old River south of Franks Tract, and at the SWP. Model EC was close to observed EC for the Middle River and the CVP. Thus, for the base condition in the alternatives analysis, the model slightly underestimates the EC at the SWP and the Old River south of Franks Tract. All modeled Franks Tract alternatives reduce the salinity transport in Franks Tract or isolate Franks Tract from Old River. As the existing condition is the basis for evaluating EC reduction at the export locations, the model may underestimate the salinity reduction benefits of the proposed alternatives.

The hydrodynamic results for the 2002 simulation period were also post-processed to compute spatial plots of changes in Delta channel velocities with the redirection of central Delta flows by each alternative configuration. A similar analysis was performed to examine the change in south Delta water levels during summertime export pumping conditions. Separate modeling runs were performed to examine alternative impacts on peak water surface elevations during the January 1997 flood and the February 1998 extreme high tide.

3.2.2 Water Quality: Site Selection and Preliminary Alternatives Analysis

At the time the study was proposed, it was thought that water quality goals might be achievable at any one of the flooded islands. Modeling of hypothetical levee breaches in the Suisun Bay and Marsh region illustrated the importance of flooded areas in the western Delta on salinity throughout the central and southern Delta. It was postulated at that time that careful management/reconfiguration of existing flooded islands, Lower Sherman Lake, Big Break, and Franks Tract, could reduce salinity intrusion into the central and southern Delta at the same time as providing ecological restoration opportunities and recreational benefits. Between the time that the study was proposed and the project was funded, reconnaissance level modeling by DWR and RMA indicated that potential water quality benefits associated with modifications to Big Break or Lower Sherman Lake were small relative to modifications in the Franks Track region. Therefore, in the pre-feasibility phase of this study, modeling efforts were focused on Franks Tract.

Franks Tract is located at the eastern edge of the late summer and fall salinity gradient, and its remnant levee configuration promotes the mixing of salt water on flood tides with freshwater entering Franks Tract from the east. Furthermore, Franks Tract is contiguous with Old River and Holland Cut, the channels that convey fresh water from the northern Delta to the drinking water export/diversion facilities in the south Delta. The location and hydrodynamics of Lower Sherman Lake and Big Break, on the other hand, do not appear to increase salt content of water in the central and south Delta. To the contrary, Lower Sherman Lake appears to dilute the saltier water of the San Joaquin River with fresher water from the Sacramento River. Constructing gates, barriers, or levees in Lower Sherman Lake would simply divert this freshwater input around the tip of Sherman Lake, increasing salinities in the San Joaquin River. Big Break, unlike Franks Tract and Lower Sherman Lake, is not in a place where freshwater and saltwater actively mix in a way that attracts the regional structure of the salt field. There is very little mixing of salinity between Big Break and Old River via Dutch Slough because of the long length and limited conveyance capacity of Dutch Slough. Similarly, Big Break does not play a significant role in the exchange of water from the Sacramento River because of its location south of the San Joaquin River. As a result, levee modifications around Big Break were not modeled. It is possible, however unlikely, that future modeling runs could show that reconfiguration of Big Break may change salinity in the south Delta.

In addition to identifying Franks Tract as the most effective location for modifications and improvements, means for changing the salt transport characteristics in the central Delta were also explored. Using a modeling framework as part of the study (explained in additional detail below), two basic approaches were identified: (1) reducing mixing of salinity into Franks Tract (west side solutions), and (2) reducing the exchange of salt into the fresh water corridor (east-side solutions). Interestingly, preliminary modeling simulations demonstrated both approaches have potential to reduce salt concentrations in the south Delta. An additional approach, manipulation of mixing processes, was also identified; however, this approach was not pursued in this study because preliminary results showed it to be less effective.

3.2.3 Water Quality Criteria and Fatal Flaw Analysis

The RMA model evaluated base conditions and nine alternatives for changes in salinity at the export/diversion facilities and changes to residence time in Franks Tract. The alternatives were also evaluated for constructability, impacts on recreation in and around Franks Tract, ecological impacts, and redundancy with similar alternatives.

These criteria are necessarily coarse and are intended largely as a fatal flaw analysis to screen a large number of alternatives down to a smaller, more manageable number for further, more comprehensive analysis.

IMPACT ON SALINITY

The primary criterion used for evaluating project alternatives was salinity changes at the Central Valley Project (CVP), State Water Project (SWP), and Contra Costa Water District (CCWD) export/diversion facilities. The RMA model evaluated salinity change at these sites for each alternative from May to December for the 2002 calendar year. The results of these model runs were considered both preliminary and conservative. Further modifications designed to optimize facility operations are expected to result in greater reductions in salinity.

An alternative failed to meet the salinity criteria if it did not reduce salinity at the pumps over the modeled period.

MATERIAL AVAILABILITY

The primary constraint on site modification constructability is availability of fill material available in the Delta. Approximately 50 million cubic yards (mcy) of dredge material are available in the Delta (NHI 2002). Not all of this fill material is suitable or available for use because some of it may be contaminated or may be needed for other levee improvement priorities. By comparison, the total volume of Franks Tract, Big Break, and Lower Sherman Lake below MLLW (mean lower low water) is 45 mcy, 25 mcy, and 15 mcy, respectively. Because peat soils are highly compactable, the total volume necessary to fill these islands could be approximately 50%–100% greater.

An alternative failed to meet the constructability criteria if it appeared that it exceeded the material available in the Delta.

RESIDENCE TIME

The RMA model also evaluated changes in residence time in Franks Tract. Maintaining a reasonable amount of circulation in Franks Tract may be critical to the current aquatic ecosystem, including the native and recreational fisheries, controlling the extent of Egeria, reducing mercury methylation, and increasing water temperature.

The term “residence time”, as used in this study, is a measure of how quickly water is exchanged in a given region. Long residence times may be associated with higher water temperatures and increased biological activity. In a simple stirred tank with constant inflow and outflow, residence time is easily calculated as the volume of the tank divided by the flow rate. In a complex region like Franks Tract, measuring the residence time is not as simple. Tidal flows drive water in and out of many openings around the periphery of Franks Tract, and some of the water that moved out of Franks Tract on ebb tide may return on the flood tide. Also, because Franks Track is very large, it is not completely mixed therefore, the residence time will vary from one area to another.

The numerical model was used to evaluate the residence time in by applying a continuous tracer load at a rate of 1 gram/m3 per day only to the water in Franks Tract. The tracer simulations were run for the summer period of 2002. If there was no exchange with the surrounding channels, the tracer concentration in Franks Tract would increase by 1 gram/m3 each day of the simulation. However, because water from other areas of the Delta move through Franks Tract, the concentration of tracer rises toward a dynamic equilibrium which varies spatially across Franks Tract and over time with the spring-neap tidal cycle and changes in Delta inflows and exports. The equilibrium value of tracer concentration is a direct measure of residence time in Franks Tract. In the surrounding Delta channels the tracer concentration provides an indication of the region influence by Franks Tract, and the tracer concentration can be interpreted as the average time that water at any channel location had previously been in Franks Tract.

Several circulation studies of water bodies in general, in San Francisco Bay as well as coastal lagoons, indicate that a residence time of less than 20 days is desirable. This is based on limiting the potential for algal blooms, without considering other effects, such as DO and concentrations of pollutants. For example, Discovery Bay with its system of siphons and pumps, maintains a residence time of less than 30 days, even though they are in an environment that is warmer and has a lower tidal exchange. Bel Marin Keys in San Pablo Bay (although in a more saline environment) has a summer residence time of approximately 90 days without any significant algal bloom related problems (Krone and Associates 1987).

In general, algae production in the Delta is primarily limited by light and to a lesser extent, by temperature (i.e., by thermal limits on the maximum growth rate); inorganic carbon; and high levels of contaminants, such as copper. Nutrients, such as phosphorus and nitrogen are rarely limiting (Jassby et al. 2002). More recently, M&N (2004) applied a simple model developed by DiToro et al. (1971), which describes algae growth, death (e.g., function of respiration, bottom grazing, and feeding by zooplankton), and interaction with flushing characteristics, to evaluate lagoon water quality in a proposed lagoon in Bethel Island. The calculations indicated that if there is an ample supply of nutrients in the water column and if environmental conditions, such as temperature and light, are optimal, the growth rate of algae will exceed the death rate in about 9 days for a water body in these latitudes. This does not by itself indicate that blooms will occur, because the total population has to increase substantially for that to happen, which would be possible only if conditions ideal for growth of algae persist over an extended period. Also, the calculations do not consider nutrient limitations, inorganic carbon supply, and other algae death mechanisms, such as grazing by zooplankton and benthic organisms.

IMPACT ON RECREATION

The most significant impact on recreation identified with any of the alternatives was the loss of boat passage caused by gates and levees or the inconvenience associated with boat locks. The extent and location of these barriers was important in assessing impacts on recreation. Some alternatives have the potential to enhance recreation by incorporating beaches, mooring areas, and other recreational features into levees. The potential for these features to off-set some of the loss in boat passage was considered in assessing the alternatives.

An alternative failed to meet the recreation criteria if it entirely prevented boat passage through Franks Tract or significantly reduced boat access and passage from Bethel Island marinas onto Franks Tract.

SIMILARITY TO OTHER ALTERNATIVES

Alternatives with similar footprints, geographies, or toolkit features were grouped into the categories described above. Of any given category, if one or two alternatives were clearly superior to other similar alternatives, they were advanced for further analysis. The alternatives that were not advanced are not necessarily eliminated from consideration. Rather, the superior alternatives serve as proxies for the entire category.

3.3 PRELIMINARY WATER QUALITY ALTERNATIVES ANALYSIS DESCRIPTION AND ASSESSMENT

3.3.1 PRELIMINARY ALTERNATIVE—NO FRANKS TRACT

The No Franks Tract preliminary alternative removes the hydraulic connection between Franks Tract and its surrounding channels by constructing levees all the way around Franks Tract. Strictly from a salinity perspective, a similar effect could be accomplished by repairing all the levees around Franks Tract and leaving the interior inundated, yet disconnected from the channels that surround Franks Tract. The No Franks Tract preliminary alternative improvement elements are depicted in Exhibit 3.3-1 and fatal flaw matrix is detailed in Exhibit 3.3-2.

DISCUSSION

The No Franks Tract alternative was designed as a bracketing "bookend" alternative to better understand the hydrodynamic function of Franks Tract in the Delta. Under this alternative, salinity at the export/diversion facilities is slightly reduced in late summer and autumn. This is likely due to the fact that when Franks Tract is isolated, it no longer creates tidal mixing or pumping. The very small increase in early summer salinity at the pumps is likely due to the fact that in the spring, Franks Tract serves as a freshwater reservoir, and its isolation slightly increases tidal excursion of salt water into the central and south Delta.

Despite the ecological benefit of a 3,300-acre tidal marsh, the No Franks Tract alternative requires more fill material than is available in the Delta. The volume of material necessary to fill Franks Tract to mean lower low water is somewhere between 45 and 90 mcy, depending on compaction of the underlying substrate. This exceeds the 50 mcy of dredge materials in the Delta, much of which may be unsuitable for this use.

Franks Tract currently provides aquatic habitat for seasonally migratory fish species as well as seasonal and permanent habitat for resident fish species. Although Franks Track lacks habitat diversity, it has been colonized by nonnative SAV. Existing levee breaches have been identified as locations of increased vulnerability of juvenile and other fish life stages to predation mortality. Eliminating Franks Tract as aquatic habitat would reduce the availability of subtidal open water habitat within the central Delta. The loss of aquatic habitat within Franks Tract, either through filling or isolation and reclamation, would represent an adverse effect to the fishery community, including the loss of recreational fisheries currently supported by Franks Tract.

It may be possible to reconstruct the levees around Franks Tract and leave the interior flooded, but that would create undesirable aquatic conditions inside of Franks Tract (warm, stagnant water that may encourage increased algal blooms, cyanobacteria, mercury methlyation, and/or mosquito production). It would also eliminate boat passage through Franks Tract, negatively affecting recreation in and around Franks Tract.

3.3.2 PRELIMINARY ALTERNATIVE—WEST FALSE RIVER GATE

The West False River Gate alternative places an operable gate across west False River (near the confluence with the San Joaquin). For the sake of preliminary modeling, the gates are closed on flood tide and allow one-third of the on ebb tide flows to pass (approximately 20,000 cfs). The West False Gate preliminary alternative improvement elements are depicted in Exhibit 3.3-3 and fatal flaw matrix is detailed in Exhibit 3.3-4.

DISCUSSION

The West False River Gate alternative produces some of the greatest salinity reductions at the diversion/export facilities. It does so by blocking the most direct route of salt water intrusion into Franks Tract. By closing the gates on flood tides, salt water is forced up the San Joaquin River, which has fewer embayments and bifurcations, allowing for less tidal pumping and mixing. Salinity benefits at the pumps would certainly improve by further optimizing operation of the gates.

When in place (twice a day during the summer and fall) the gates block boat passage to Franks Tract from the San Joaquin River, although traffic can enter via Fisherman's Cut. It is assumed that the loss of boat passage could be mitigated with a navigation lock.

Operation of the gate structure during the summer and fall would contribute to a physical structure and tidal gate operation that would be expected to attract predatory fish species and increase localized predation mortality on juvenile and other fish life stages. Tidal closure of the gates would also impede fish movement and migration during the summer and fall. Gate closure, although on a tidal basis, would potentially delay and impede the upstream migration of fall-run chinook salmon and other fish that move upstream in the summer and fall months. Having the gates open throughout the winter and spring would not be expected to adversely impede the downstream migration of juvenile chinook salmon, steelhead, or the movements or distribution of fish eggs, larvae, juveniles or other life stages of migratory or resident species. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement within the area.

As a purely gate-based alternative, the West False River Gate alternative lacks intrinsic ecological or recreational benefits. Ecological and recreational improvements would be added as amenities to this alternative.

3.3.3 PRELIMINARY ALTERNATIVE—FALSE RIVER AND PIPER SLOUGH GATES

The False River and Piper Slough Gates alternative places an operable gate in west False River (alongside Little Franks Tract east of Fisherman's Cut) and an operable gate across Piper slough east of Taylor Slough. A reconstructed levee between Franks Tract and Little Franks Tract would connect the two gates. For the sake of preliminary modeling, the gates are closed on flood tide and open on ebb tide. The False River and Piper Slough Gates preliminary alternative improvement elements are depicted in Exhibit 3.3-5 and fatal flaw matrix is detailed in Exhibit 3.3-6.

DISCUSSION

The False River and Piper Slough Gates alternative is similar to the West False River Gate option. Instead of a single gate, it uses two smaller gates to the east that isolate Fisherman's Cut and Taylor Slough from Franks Tract (model results for the West False River Gate alternative showed that significant exchange of salt into Franks Tract occurs through Fisherman's Cut.). For most of the model run, the alternative performs well with respect to salinity at the diversion/export facilities. In late fall, it increases salinity. This is likely an artifact of the gate operations (which differ from those of the False River Gate alternative). The modeled gate operation encourages salinity intrusion into Franks Tract from the northeast. Optimizing gate operation could eliminate this transport mechanism and reduce salinity at the pumps in late fall.

When in place (twice a day during summer and fall) the gates block boat passage to Franks Tract from the San Joaquin River. It is assumed that the loss of boat passage could be mitigated with a navigation lock.

Similar to West False Gate alternative, operation of the gate structure during the summer and fall would contribute to a physical structure and tidal gate operation that would be expected to attract predatory fish species and increase localized predation mortality on juvenile and other fish life stages. Tidal closure of the gates would also impede fish movement and migration during the summer and fall. Gate closure, although on a tidal basis, would potentially delay and impede the upstream migration of fall-run chinook salmon and other fish that move upstream in the summer and fall months. Having the gates open throughout the winter and spring would not be expected to adversely impede the downstream migration of juvenile chinook salmon, steelhead, or the movements or distribution of fish eggs, larvae, juveniles or other life stages of migratory or resident species. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement within the area.

As a purely gate-based alternative, the False River and Piper Slough Gates alternative lacks intrinsic ecological or recreational benefits. Ecological and recreational improvements would be added as amenities to this alternative.

3.3.4 PRELIMINARY ALTERNATIVE—EAST SIDE OPEN

The East Side Open alternative repairs the levee breaches on the north (False River) and west (Piper Slough) levees, reducing hydraulic connectivity and the exchange of salt between Franks Tract and its surrounding channels. The north levee repairs extend to Old River and the west levee repairs extend to Sand Mound Slough. The East Side Open preliminary alternative improvement elements are depicted in Exhibit 3.3-7 and fatal flaw matrix is detailed in Exhibit 3.3-8.

DISCUSSION

The East Side Open alternative is a relatively simple and passive solution (no moving parts such as tidal gates) that achieves dramatic reductions in salinity at the pumps. This is accomplished by isolating tidal flows from the west to False River and Piper Slough. Both False River and Piper Slough, when repaired, are longer than the local tidal excursion, preventing salt water from entering Franks Tract. The repaired levees also offer the opportunity to create new habitat and recreational beaches.

This alternative solution however, creates its own problems. The repaired levees create a high residence time in the western corner of Franks Tract. Modeled residence time increases from 2 (base case) to 12 days. High residence time may encourage algal blooms, cyanobacteria, or mercury methlyation. More importantly, the reduced velocities in this area may encourage the spread of Egeria throughout Franks Tract.

Although the repaired levees reduce wind fetch on Bethel Island and Webb Tract, they also restrict boat traffic between Piper Slough and False River, isolating businesses and residences along Piper Slough from recreation in Franks Tract.

Closure of the existing levee breaches would also reduce connectivity and passage opportunities for fish to move into and out of Franks Tract. Migratory fish, such as juvenile chinook salmon, that move into Franks Tract may experience a longer residence time and impediments to migration out of Franks Tract, thereby increasing their potential exposure to predation mortality and other environmental conditions that may increase stress and reduce survival. Many of the juvenile fish passing into or out of Franks Tract through existing levee breaches are vulnerable to predation by fish such as striped bass and largemouth bass. Reducing the numbers of levee breaches has the potential to reduce the vulnerability of these fish to increased risk of predation.

The East Side Open alternative is similar to other alternatives (i.e., North Levee and Nozzle Gate alternative: North Levee, Nozzle Gate, and Piper Slough Gate alternative; and North Levee and Little Franks Tract Closed alternative) (discussed later), which address some of the problems encountered by this purely passive alternative.

3.3.5 PRELIMINARY ALTERNATIVE—NORTH LEVEE AND NOZZLE GATE

The North Levee and Nozzle Gate alternative reconstructs the north levee all the way to Old River and places a gate in the main nozzle between False River and Franks Tract in an attempt to avoid the residence time problems created in the East Side Open alternative. For the sake of preliminary modeling, the gates are closed on flood tide and open on ebb tide. The North Levee and Nozzle Gate preliminary alternative improvement elements are depicted in Exhibit 3.3-9 and fatal flaw matrix is detailed in Exhibit 3.3-10.

DISCUSSION

The North Levee and Nozzle Gate alternative demonstrates a slight decrease in salinity at the diversion/export facilities. The small decrease may be due to increased salt water entering Franks Tract through Piper Slough (which is not gated or leveed in this option).

The gate on the nozzle does control residence time well. Peak modeled residence time only increases by a day in Franks Tract over the base case. The repaired north levee also offers the opportunity to create new habitat and recreational beaches, and potentially reduce wind-wave fetch forces on Webb Tract. The alternative keeps Piper Slough open and only prevents boat passage directly from False River to Franks Tract. It is assumed that the loss of boat passage could be mitigated with a navigation lock.

The combination of closing existing levee breaches and operating a nozzle gate would be expected to increase the concentration and vulnerability of fish to predation mortality in the immediate vicinity of the nozzle opening. Closure of the existing levee breaches would reduce connectivity and passage opportunities for fish to move into and out of Franks Tract. Migratory fish, such as juvenile chinook salmon, that move into Franks Tract may experience a longer residence time and impediments to migration out of Franks Tract, thereby increasing their potential exposure to predation mortality and other environmental conditions that may increase stress and reduce survival. Many of the juvenile fish passing into or out of Franks Tract through existing levee breaches are vulnerable to predation by fish such as striped bass and largemouth bass. Reducing the numbers of levee breaches has the potential to reduce the vulnerability of these fish to increased risk of predation. Concentrating the tidal flow and concentration of fish vulnerable to predation within the nozzle area, however, may result in an overall increase in the local concentration of predatory fish in the area. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement within the area.

3.3.6 PRELIMINARY ALTERNATIVE—NORTH LEVEE, NOZZLE GATE, AND PIPER SLOUGH GATE

The North Levee, Nozzle Gate, and Piper Slough Gate alternative reconstructs the north levee to Old River. The alternative includes a gate in the main nozzle between False River and Franks Tract in an attempt to avoid the residence time problems created in the East Side Open alternative. The alternative also includes a gate on Piper Slough to prevent salt water from entering via Piper Slough yet maintain partial boat passage between Piper Slough and Franks Tract. For the sake of preliminary modeling, the gates are closed on flood tide and open on ebb tide. The North Levee, Nozzle Gate, and Piper Slough Gate preliminary alternative improvement elements are depicted in Exhibit 3.3-11 and fatal flaw matrix is detailed in Exhibit 3.3-12.

DISCUSSION

The North Levee, Nozzle Gate, and Piper Slough Gate alternative effectively reduces salinity at the diversion/export facilities by isolating Franks Tract from tidal flows from the west. The inclusion of the gates avoids the problems of residence time in western Franks Tract encountered in the East Side Open alternative. Peak modeled residence time in western Franks Tract increases from 2 days to 3 days. The repaired north levee also offers the opportunity to create new habitat and recreational beaches, and reduce wind-wave fetch forces on Webb Tract. The alternative keeps Piper Slough open to Franks Tract and only prevents boat passage directly from False River to Franks Tract and from False River to Piper Slough when the gates are in operation. It is assumed that the loss of boat passage could be remediated with a navigation lock.

Similar to West False Gate alternative, the combination of closing existing levee breaches and operating a nozzle gate would be expected to increase the concentration and vulnerability of fish to predation mortality in the immediate vicinity of the nozzle opening. Closure of the existing levee breaches would reduce connectivity and passage opportunities for fish to move into and out of Franks Tract. Migratory fish, such as juvenile chinook salmon, that move into Franks Tract may experience a longer residence time and impediments to migration out of Franks Tract, thereby increasing their potential exposure to predation mortality and other environmental conditions that may increase stress and reduce survival. Many of he juvenile fish passing into or out of Franks Tract through existing levee breaches are vulnerable to predation by fish such as striped bass and largemouth bass. Reducing the numbers of levee breaches has the potential to reduce the vulnerability of these fish to increased risk of predation. Concentrating the tidal flow and concentration of fish vulnerable to predation within the nozzle area, however, may result in an overall increase in the local concentration of predatory fish in the area. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement within the area.

3.3.7 PRELIMINARY ALTERNATIVE—NORTH LEVEE AND CLOSE LITTLE FRANKS TRACT

The North Levee and Close Little Franks Tract alternative reconstructs the north levee to Old River. The alternative also reconstructs the levee around Little Franks Tract to prevent tidal flows from short-circuiting through Little Franks Tract. The North Levee and Close Little Franks Tract preliminary alternative improvement elements are depicted in Exhibit 3.3-13 and fatal flaw matrix is detailed in Exhibit 3.3-14.

DISCUSSION

The North Levee and Close Little Franks Tract alternative demonstrates a slight decrease in salinity at the diversion/export facilities. The decrease is small because of increased salt water entering Franks Tract through Piper Slough (which is not gated or leveed in this option). Less salt water enters through Piper Slough than in the North Levee and Nozzle Gate alternative as a result of eliminating the hydraulic short circuit through Little Franks Tract.

Peak modeled residence time increases in northern Franks Tract from 2 to 6 days. Residence time may decrease with optimized gate operation. The repaired north levee offers the opportunity to create new habitat and recreational beaches, and reduce wind-wave fetch forces on Webb Tract. The alternative keeps Piper Slough open and only prevents boat passage directly from False River to Franks Tract. It is assumed that the loss of boat passage could be remediated with a navigation lock.

The combination of closing existing levee breaches and operating a nozzle gate would be expected to increase the concentration and vulnerability of fish to predation mortality in the immediate vicinity of the nozzle opening. Closure of the existing levee breaches would reduce connectivity and passage opportunities for fish to move into and out of Franks Tract. Migratory fish, such as juvenile chinook salmon, that move into Franks Tract may experience a longer residence time and impediments to migration out of Franks Tract, thereby increasing their potential exposure to predation mortality and other environmental conditions that may increase stress and reduce survival. Many of the juvenile fish passing into or out of Franks Tract through existing levee breaches are vulnerable to predation by fish such as striped bass and largemouth bass. Reducing the number of levee breaches has the potential to reduce the vulnerability of these fish to increased risk of predation. Concentrating the tidal flow and concentration of fish vulnerable to predation within the nozzle area, however, may result in an overall increase in the local concentration of predatory fish in the area. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement within the area.

Closure of levee breaches within Little Franks Tract as part of this alternative would reduce the availability of aquatic habitat for fish within the central Delta.

3.3.8 PRELIMINARY ALTERNATIVE—EAST LEVEE AND GATES

The East Levee and Gates alternative reconstructs the east levee along Old River and constructs gates between Old River and False River, and Old River and Sand Mound Slough. For the sake of preliminary modeling, the False River and Sand Mound Sough gates were modeled as barriers. The East Levee and Gates preliminary alternative improvement elements are depicted in Exhibit 3.3-15 and fatal flaw matrix is detailed in Exhibit 3.3-16.

DISCUSSION

Rather than isolating salt water from Franks Tract, the East Levee and Gates alternative isolates Franks Tract from the channels that convey Franks Tract water to the export/diversion facilities in the south Delta. Franks Tract is allowed to mix salt water, but the levee and operable gates along Old River prevent salty water from exchanging into Old River.

The East Levee and Gates alternative demonstrates a significant reduction in salinity at the pumps that may improve with optimized operation of the gates. In part because the model kept the gates closed, modeled residence time increases dramatically in the southern part of Franks Tract from 3 to 12 days, but this may also be reduced with operation of the gates.

The repaired east levee offers the opportunity to create new habitat and recreational beaches, and reduce wind-wave fetch forces on Mandeville Island.

When in place (anticipated to be twice a day during the summer and fall) the gates block boat passage to Franks Tract from Discovery Bay and locations south on Old River and Middle River. It is assumed that the loss of boat passage could be remediated with a navigation lock.

Operation of the gate structures during the summer and fall would contribute to a physical structure and tidal gate operation that would be expected to attract predatory fish species and increase localized predation mortality on juvenile and other fish life stages. Tidal closure of the gates would also impede fish movement and migration during the summer and fall. Gate closure, although on a tidal basis, would potentially delay and impede the upstream migration of fall-run chinook salmon and other fish that move upstream in the summer and fall months. Having the gates open throughout the winter and spring would not be expected to adversely impede the downstream migration of juvenile chinook salmon, steelhead, or the movements or distribution of fish eggs, larvae, juveniles or other life stages of migratory or resident species. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement within the area.

Closure of the existing levee breaches would reduce connectivity and passage opportunities for fish to move into and out of Franks Tract. Migratory fish, such as juvenile chinook salmon, that move into Franks Tract may experience a longer residence time and impediments to migration out of Franks Tract, thereby increasing their potential exposure to predation mortality and other environmental conditions that may increase stress and reduce survival. Many of the juvenile fish passing into or out of Franks Tract through existing levee breaches are vulnerable to predation by fish such as striped bass and largemouth bass. Reducing the numbers of levee breaches has the potential to reduce the vulnerability of these fish to increased risk of predation.

3.3.9 PRELIMINARY ALTERNATIVE—COX ALTERNATIVE

The Cox alternative places barriers on either side of Quimby Island in Old River and Holland Cut. This alternative was first suggested by the late Gerry Cox in the late 1980's (Enright, pers. comm., 2005).[2] For the sake of preliminary modeling, the barriers were not operable. The Cox preliminary alternative improvement elements are depicted in Exhibit 3.3-17 and fatal flaw matrix is detailed in Exhibit 3.3-18.

DISCUSSION

Rather than isolating salt water from Franks Tract, the Cox alternative completely eliminates transport of salt from Old River to the export/diversion facilities in the south Delta. Franks Tract at the San Joaquin River above Franks Tract is allowed to mix salt water, but the barriers on Old River and Holland Cut prevent much of that water from passing south.

The Cox alternative achieves a significant reduction in salinity at the pumps that may improve with optimized operation of the gates. Modeled residence time is increased in the southern part of Franks Tract from 3 to 7 days, however, this may also be reduced with modified operation of the barriers.

As a purely barrier-based alternative, the Cox alternative lacks ecological or recreational benefits. Ecological and recreational improvements would be added as amenities to this alternative.

Operation of the gate structures during the summer and fall would contribute to a physical structure and tidal gate operation that would be expected to attract predatory fish species and increase localized predation mortality on juvenile and other fish life stages. Tidal closure of the gates would also impede fish movement and migration during the summer and fall. Gate closure, although on a tidal basis, would potentially delay and impede the upstream migration of fall-run chinook salmon and other fish that move upstream in the summer and fall months. Having the gates open throughout the winter and spring would not be expected to adversely impede the downstream migration of juvenile chinook salmon, steelhead, or the movements or distribution of fish eggs, larvae, juveniles or other life stages of migratory or resident species. The specific effects of gate operation on fish migration would depend on seasonal and daily operations, water velocities and turbulence associated with gate opening, and the seasonal timing of fish movement within the area.

When in place (during the summer and fall) the barriers block boat passage to Franks Tract from Discovery Bay and locations south. It is assumed that the loss of boat passage could be remediated with a navigation lock.

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[2] Formerly known as "Quimby Barriers", the Cox alternative was initially modeled by Gerry Cox and Chris Enright of DWR in 1989 using the DSM1 model.

3.3.10 WATER QUALITY ALTERNATIVES SUMMARY AND SCREENING

The preliminary alternatives summary comparison matrix (Exhibit 3.3-19) displays the results of the fatal flaw analysis. Two alternatives have fatal flaws that prevent considering them further. The No Franks Tract alternative requires more fill material than is available and greatly impacts existing recreation in Franks Tract. The East Side Open increases residence time and creates stagnant pockets of water that may enhance the growth of Egeria and other undesirable species.

For the remaining water quality alternatives, one alternative for each group will represent the entire group in the comprehensive alternative analysis. For each group, the alternative with the greatest salinity improvement at the export/diversion facilities was selected.

The four water quality alternatives to be included in the comprehensive alternative analysis are:

- West False River Gate;
- North Levee, Nozzle Gate, and Piper Slough Gate;
- East Levee and Gates; and
- Cox Alternative.

3.4 ECOSYSTEM RESTORATION SITE SELECTION CRITERIA

The preferred ecosystem restoration tools identified in Table 3-1.1 could be applied in many different locations on any of the flooded islands. However, as discussed in the Conceptual Alternatives Report, there is simply not enough fill material currently available to create tidal marsh or habitat levees across or around all of the flooded islands. Furthermore, the cost of creating these habitats is potentially very high due to the cost of excavating and transporting fill material. Therefore, analysis was conducted to identify the most promising sites for restoring tidal marsh and creating habitat levees to cost effectively utilize limited fill resources.

3.4.1 TIDAL MARSH

Potential tidal marsh restoration sites were identified and evaluated (see Table 3.4-1) based on the criteria listed below in order of importance. This analysis is intended to show the reader how the most promising sites were identified. It is not a deterministic screening tool designed to eliminate sites from future consideration. The final rank for each site was determined based on a qualitative assessment of the scores for each criterion. The final rank is largely determined by the amount of fill material per acre needed to accomplish restoration, but this quantitative criterion is balanced against other considerations such as proximity to deeper channels or potential patch size.

In addition to the criteria listed below, consideration was also placed on creating a spatially integrated, logical package of actions. Because reducing salinity in the central and south Delta was determined to be most effective by making modifications at Franks Tract, ecosystem

Table 3.4-1
Tidal Marsh Restoration Site Evaluation Matrix

	Avg. Depth (below MLLW)	Substrate Type	Maximum Size	Potential Patch Size**	New Edge	Erosion Risk	Proximity to High Velocity	SAV-Free Deep Water	Topographic Diversity	Fill per acre (per 1,000 cubic yds)	Rank
Decker*	NA	mineral	400	—	—	—	—	—	—	–50.0	high
Sherman Lake											
West Central Sherman Lake	4	organic	315	large	small	medium	good	yes	low	17.1	medium
East Central Sherman Lake	8	organic	501	large	medium	high	good	yes	low	29.6	low
Big Break											
Central Point—Big Break	3	mixed	173	large	small	medium	poor	no	medium	3.6	medium
Eastern Big Beak	4	mixed	200	large	medium	medium	poor	no	medium	0	medium
Western Big Break	4	mixed	135	large	large	medium	good	yes	low	12.8	medium
Little Franks Tract											
West Little Franks	4	organic	103	medium	small	low	good	yes	low	17.1	medium
Central Little Franks	6	organic	87	small	small	low	good	yes	low	23.3	low
East Little Franks	4	organic	91	small	small	low	good	yes	low	17.1	medium
Horseshoe Point	3	mineral	87	small	small	low	poor	yes	medium	7	medium
Franks Tract											
S.W. Franks Tract	4.5	mineral	176	medium	small	low	good	yes	low	9.3	high
N.W. Franks Tract	6	organic	59	medium	small	low	good	yes	low	23.3	low
North Nozzle	5	mineral	17	small	small	medium	good	yes	low	10.1	medium
Skaggs Island	4	mineral	21	small	medium	high	good	no	low	8.6	medium
S.E. Levee	4	mineral	129	medium	small	high	good	no	low	8.6	high
East Levee	5	mixed	104	medium	large	high	good	no	low	15.2	medium
N. Levee	4.5	organic	40	medium	small	high	good	no	low	18.7	medium
Central Franks Tract	8	organic	500	large	large	low	poor	no	low	14.8	medium
13 Linear Islands	8	organic	110	small	large	high	poor	yes	low	36.9	NA
Subtotal	—	—	3,248	—	—	—	—	—	—	—	—

*Above MLLW (mean lower low water). Necessary fill source for other sites.
**Potential patch size considers proximity to existing marsh areas or planned restoration sites
SAV = submerged aquatic vegetation

restoration siting was biased in favor of restoring/creating habitat at or near this study area. Additionally, habitat restoration at Lower Sherman Lake was dismissed because it is already provides relatively good habitat (Grimaldo, pers. comm., 2004), therefore, it did not make sense to propose alterations at that study area. Furthermore, Little Franks Tract provides unique opportunities for manipulating primary productivity and/or restoring habitat because of the relatively confined nature of this site. Restoration at Little Franks could also reduce wind wave erosion on Bethel Island – something important to the Bethel Island stakeholders. Thus, Little Franks Tract is identified as a restoration site where a range or strategies should be considered.

< *Depth of flooded area or subsidence:* This is a simple measure of the depth of flooded areas below sea level. Because of known fill availability constraints, targeted areas were less than 6 feet in depth, with an average depth of 4 feet.

< *Substrate type and associated compaction factors:* Substrates were classified into three types: mineral, organic, and mixed and targeted mineral soil sites. Numerous mixed and organic soil sites were selected because of lack of mineral soil areas and a general lack of good data regarding soil type on flooded islands.

< *Size of restoration area and proximity to existing marsh areas:* Size of restoration area and proximity to existing marsh areas is based on the assumption that large patch sizes of marsh are necessary to support dendritic tidal marsh (Reed and DiGenero 2002) and are otherwise preferable to native fish species compared to small patch sizes. Potential patch size was calculated by adding the maximum acreage of the potential restored site (given depth and substrate constraints) with the acreage of existing adjacent marsh areas.

< *Potential length of edge habitat:* Length of edge habitat was assumed a desirable feature but deemed it less important than patch size.

< *Erosion risk:* Erosion risk was estimated based on prevailing wind patterns and known high velocity areas, such as the “nozzle” in western Franks Tract. The most erosive wind-waves were assumed to be associated with frontal weather patterns from the southwest as well as northwestern winds.

< *Proximity to high-velocity channels:* Marshes adjacent to high-velocity channels would be more likely to be used by native juvenile and larval fish species traveling in the channels, and would allow for maximum exchange of water and nutrients to and from the marsh areas.

< *Potential for access to restored marsh via deep, SAV free water:* Deep-water areas (greater than 12 feet deep) are less likely to be colonized by submerged aquatic vegetation (SAV) than are shallow water areas (Anderson, pers. comm., 2004).

- *Potential for topographic diversity:* Sites with greater potential for topographic area were given preferential bias under the assumption that topographic diversity would result in habitat diversity and associated species diversity. Mainland sites near Big Break were the only sites with greater potential for topographic diversity due to their proximity to upland areas on the edge of the Delta. Potential sites in flooded and subsided islands have less potential for topographic diversity, although such diversity could be designed into the project by simply adding more fill material.

Several large but discrete tidal marsh restoration sites were identified, with the objective of significantly increasing tidal marsh area in the western Delta. This pursuit of maximizing tidal marsh restoration, however, was tempered with the knowledge that area of restored tidal marsh would ultimately be constrained by the amount of fill available. Therefore, only areas less than 6 feet below mean lower low water were targeted.

Increasing the quality and availability of tidal marsh habitat as part of the proposed alternatives offers potential fishery benefits. Tidal marsh provides important shallow water habitat, dendritic channels, habitat cover, diversity, and complexity that are frequently used by rearing juvenile fish. Tidal marsh also serves to increase the production of aquatic macroinvertebrates that are an important prey resource for larval and juvenile fish. Adult life stages of several Delta fish species, including splittail, actively forage within tidal marshes (USFWS 1996). Inundated emergent and submerged aquatic vegetation also provide a hard substrate for spawning by several Delta fish species as well as cover and rearing habitat (USFWS 1996). Tidal marshes provide increased organic matter and nutrients that directly and indirectly benefit fish and the aquatic community inhabiting the estuary. The magnitude of these fishery benefits depends, in part, on the size and characteristics of the tidal marsh, tidal flows within the marsh, vegetation types and densities, proximity to shallow and deep open water areas, tidal flushing and circulation, and habitat complexity including the dendritic tidal channels. These fishery benefits vary among different potential alternative tidal marsh sites evaluated as part of this pre-feasibility study (Table 3.4-1).

A total of 18 flooded island restoration sites, plus Decker Island, were evaluated with a combined total of 3,200 acres and a total fill requirement of approximately 50 mcy. This compares to the 20 mcy available from Decker Island, another theoretical 35 mcy available from other upland dredged material sites (including Brannan Island), and 2–5 mcy from dredging flooded island sites. In reality, the fill constraints dictate that it may only be possible to restore roughly half these sites.

Table 3.4-1 evaluates 18 different marsh restoration options according to the criteria described above and provides a preliminary ranking of the alternatives. Rank is based on the amount of fill required per acre, combined with a qualitative assessment of the other criteria. The amount of fill per acre and the corresponding rank for each site is highly sensitive to compaction rate estimates. Compaction rate estimates are rough approximations as a result of lack of data on substrate types for the flooded island sites and a lack of data on actual compaction rates where soil types are better known. A compaction rate of 2 for peat soils, 1.5 for mixed soils, and 1 for mineral soils was assumed. Areas with a compaction rate of 2 required twice as much fill as similarly deep sites with mineral soils. Subsequent analysis is necessary to better characterize substrate types and estimate likely compaction rates.

Despite the uncertainties associated with substrate and compaction factors, Table 3.4-1 clearly identifies some of the most and least promising options. Restoration of shallow mineral substrate areas, such as “southwest Frank Tract,” appears promising, whereas restoration of deep organic sites, such as central Franks Tract or western Lower Sherman Lake, are impractical.

Depth, substrate, and size characteristics were most amenable to quantification. Based on a combination of depth and substrate (mineral vs. organic), approximate amounts of fill necessary per acre of marsh restored were estimated. This provided a robust measure of the cost efficiencies associated with different sites.

3.4.2 HABITAT LEVEES

Preferred habitat levee locations were selected based on the following criteria:

- Proximity to the windward side existing remnant levee and mid channel habitat vulnerable to erosion: Habitat levees constructed on the windward side of remnant levees and mid-channel islands would generally help protect these remnant habitats from wind-wave erosion.

- Depth: areas with depths of 6 feet or less: It is far less expensive to build remnant levees in shallower areas. A depth of 6 feet was selected because there is relatively little area less than six feet deep on the flooded islands, except around their perimeters, but there is a large area deeper than 6 feet through their interiors, particularly on Franks Tract and Sherman Lake.

- Adjacency to deep, high-velocity channels with minimal SAV: Areas adjacent to deep, high velocity channels are preferred because it is assumed that there is a lower risk of Egeria colonization. Habitat levees and marsh would presumably provide more benefit for native fishes if they were adjacent to deep, fast moving water rather than shallow, Egeria infested waters.

- Adjacency to migratory fish routes: Habitat levees along known fish migration routes such as the Sacramento River would presumably provide more benefit to native fish then habitat levees constructed in areas more distant from fish migration routes such as the south shore of Big Break.

- Proximity to undeveloped shoreline: Protection of remnant habitat would presumably be more beneficial if it protected habitat that was not already degraded by nearby shoreline development.

<   Potential impact on navigation: Habitat levees across areas currently used for navigation would presumably impede navigation and thereby undermine the recreation objective of this study.

<   Wind-wave reduction benefit: Habitat levees that reduce wind wave erosion on neighboring islands would contribute to the flood protection objectives of this project.

Table 3.4-2 evaluates the potential sites for protecting remnant levee habitat with new habitat levees. The purpose of the analysis is intended to show the reader how the most promising sites were identified. Sites that met all the criteria are ranked high while sites that satisfied only a limited number of the criteria scored low. Each criterion was equally weighted.

New habitat levees along the north remnant levee of Franks Tract and Little Franks Tract could protect and enhance a large corridor of habitat along the False River fish migration route. Habitat levees along the north and south sides of Little Franks Tract could prevent wind-wave erosion forces on Bethel Island from northerly winds that may increase as the Little Franks Tract levees continue to deteriorate. Habitat levees along the south shore of Franks Tract would also reduce wind-wave erosion along the developed shore of Bethel Island, but may not result in high quality habitat because of the proximity of marinas and other development. Furthermore, a continuous habitat levee would impede navigation between the Bethel Island shore and Franks Tract. Habitat levees along the north shore of Big Break would create a habitat corridor between the San Joaquin River and the Dutch Slough restoration project.

3.4.3 EMPLOY OPERABLE GATE TO ENHANCE PRIMARY PRODUCTIVITY

The site selection criteria for enhancing primary productivity include:

<   proximity to water quality gates; and
<   short wind-wave fetch from northerly winds.

The only site that meets both these criteria is Little Franks Tract.

3.5 RECREATION: EVALUATION CRITERIA AND SITE SELECTION ANALYSIS

Overall, several opportunities are possible for enhancing existing and promoting new recreational opportunities in the study area. Facilities where site conditions would determine installment include beaches, picnic areas, docks, signage, floating campsites, floating restrooms, picnic sites, and floating wildlife viewing/picnic platforms.

3.5.1 RECREATIONAL FACILITIES ASSOCIATES WITH TIDE GATES AND BARRIERS

As mentioned above, recreational facilities associated with tide gates and barriers include the following:

Table 3.4-2
Habitat Levee Site Selection Matrix

	Protects Remnant Levee Habitat	Depth of 6 feet or Less	Adjacent to Deep Water Channel	Adjacent to Fish Route	Undeveloped Shoreline	Minimal Navigation Conflict	Wind-Wave Mitigation	Rank
North Levee of Franks Tract	✓	✓	✓	✓	✓	✓	✓	High
Northeast Levee of Franks Tract		✓	✓		✓		✓	Low
Southeast Levee of Franks Tract	✓	✓	✓		✓		✓	Low
North levee of Little Franks Tract	✓	✓	✓	✓	✓	✓	✓	High
South Levee of Little Franks Tract	✓	✓	✓		✓	✓	✓	High
West Levee of Franks Tract	✓	✓	✓				✓	Low
South Levee of Franks Tract	✓	✓	✓		✓	✓	✓	Medium
North Levee of Big Break	✓	✓	✓	✓	✓	✓	✓	High
South Shore of Big Break		✓			✓	✓		Low
North Shore of Sherman Lake			✓	✓	✓			Low
South Shore of Sherman Lake			✓	✓	✓			Low

- boat navigation locks;
- mooring and docking areas;
- boat launches; and
- general store, restrooms, fueling station, pump-out station, boat rental office, and parking lots.

Boat navigation locks are assumed to be located at all gates/barriers. Relatively large locks would allow for several recreational boats to pass through at once, allowing easy boat passage and limiting congestion. Additional recreational facilities may be incorporated into gates and barriers at locations where adequate space away from the structure is available to ensure safety.

3.5.2 RECREATIONAL IMPROVEMENTS

Recreational improvements include the following:

- beaches;
- mooring and docking areas; and
- floating campgrounds.

Although evaluation of specific sites for potential facilities is dependent on design specifics, engineering and cost constraints, and the need for further information on factors such as boat traffic patterns and wildlife needs, some attempt can be made to identify which study sites have the best potential for certain new facilities.

At Franks Tract, beaches are possible along new levees and within existing “pockets” at several different locations. Lower Sherman Lake and Big Break have not been identified as sites for levee repair or modification to improve water quality. Thus, beach construction opportunities would need to be evaluated purely as recreation enhancements. Floating restroom placement would best be determined in coordination with other improvements, such as mooring areas, beaches, and other enhancements, which are most likely to be located at Franks Tract.

Mooring sites should be sited in boater-friendly open areas in concurrence with Egeria removal and dredging. Mooring areas could also be created in concurrence with other amenities, such as pocket beaches created adjacent to new levees. Mooring areas would be most advantageous at Franks Tract because of higher use at this site and potential for other amenities, such as beaches, to be located there. These amenities could be developed in association with the mooring areas.

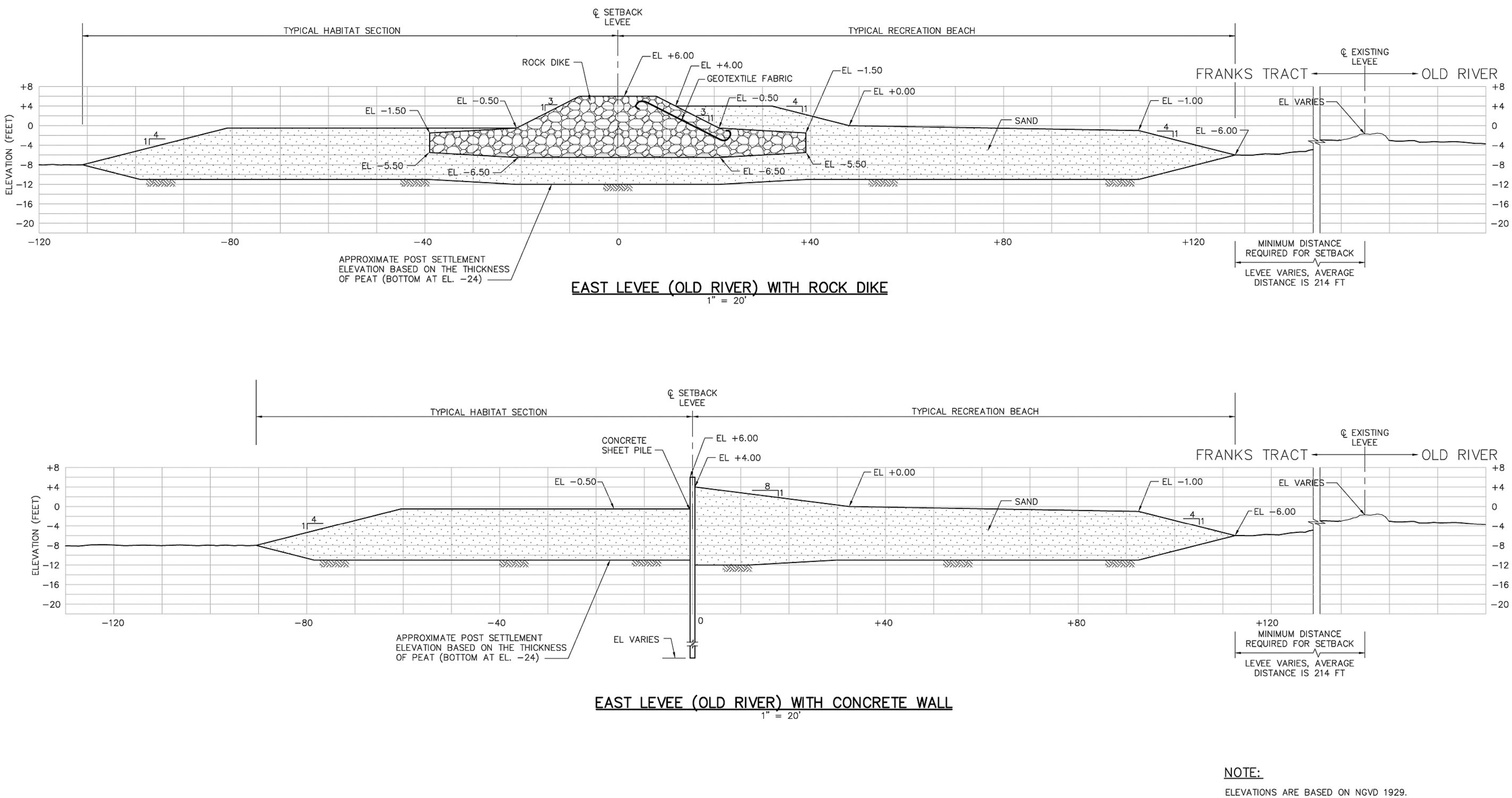
Floating campsite locations are more suitable for Big Break and Franks Tract than Lower Sherman Lake because of strong winds at that site, although wind is an issue at all three sites. Floating campsites at either Big Break or Frank’s Tract would require careful placement and anchoring and possibly wind breaks.

3.6 SUMMARY

Table 3.6-1 below summarizes the findings and conclusions of the preliminary evaluation of toolkit options, the preferred toolkit, and the best locations and configurations for application of the tools. The table also identifies promising toolkit options that require further study.

Table 3.6-1
Preferred Toolkit Evaluation Summary

	Water Quality	Ecosystem	Recreation
Toolkit	< Levees < Permanent and seasonal barriers < Operable gates	< Using dredged material to create tidal marsh < Habitat levees < Enhancing primary productivity	< Boat navigation locks < Facilities and gates and barriers < Pocket beaches < Floating campgrounds < Mooring areas < Picnic areas
Preferred site locations and configurations	< West False River Gate < North Levee, Nozzle Gate and Piper Slough Gate < East Levee and Gates < Cox Alternative (gates on Old River and Holland Cut)	< Tidal marsh in SW Franks Tract < Habitat levee on SE Franks Tract Levee < Habitat levee on North Levee < Tidal marsh and enhancing primary productivity in Little Franks Tract interior < Habitat levee on Little Franks Tract north levee < Habitat levee on Little Franks Tract south levee	< Tidal gate and barrier locations < Sheltered areas (wind and wind-wave fetch) < Associate complimentary recreational elements with each other
Toolkit options worthy of future study	< Optimizing gate operation	< Elevating peat substrate on Little Franks Tract to create tidal marsh < Managing residence time to enhance primary productivity.	< Egeria control methods < Experimental dredging techniques



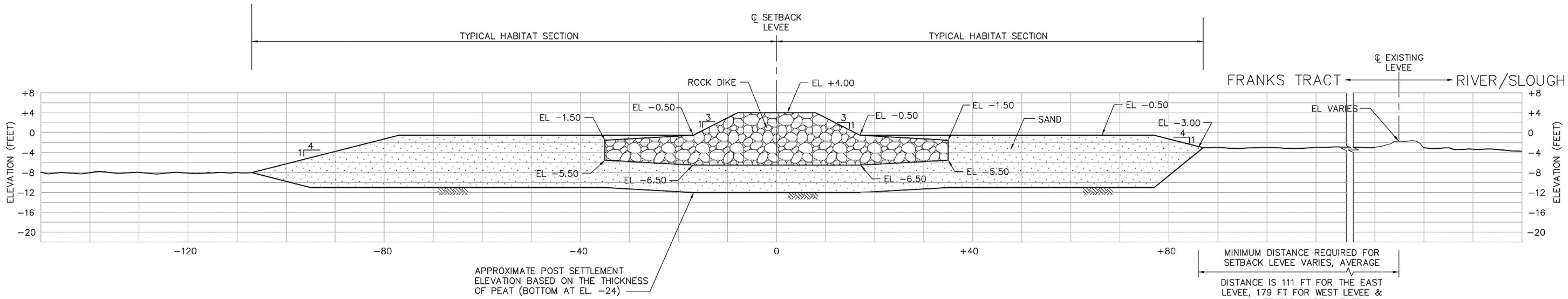
Source: Moffat & Nichol 2005

Typical Habitat/Beach Levee

EXHIBIT 3.1-2

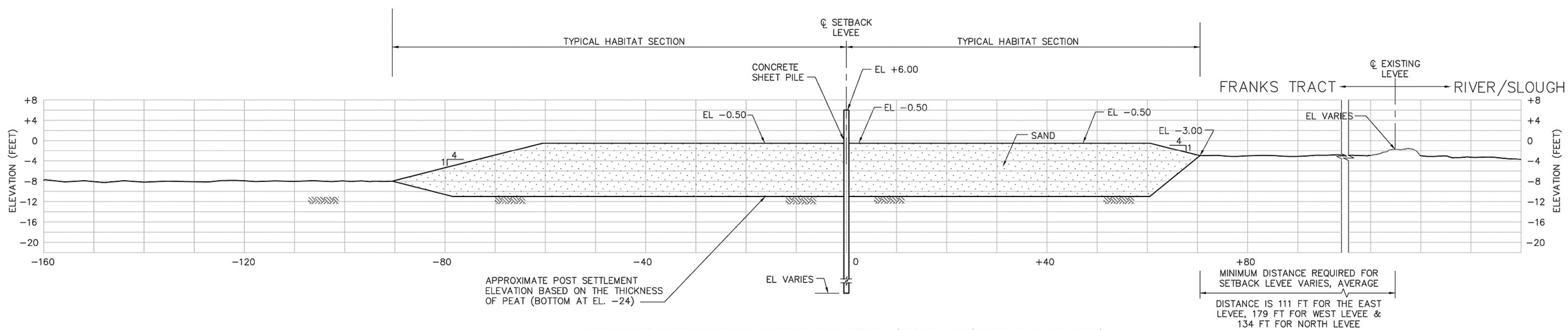
Flooded Islands Pre-Feasibility Study Report
P 04110052.03 04/05

0 11 22
FEET
NORTH
EDAW



SETBACK LEVEE WITH ROCK DIKE (HABITAT/HABITAT OPTION)

1" = 20'



SETBACK LEVEE WITH CONCRETE WALL (HABITAT/HABITAT OPTION)

1" = 20'

NOTE:

ELEVATIONS ARE BASED ON NGVD 1929.

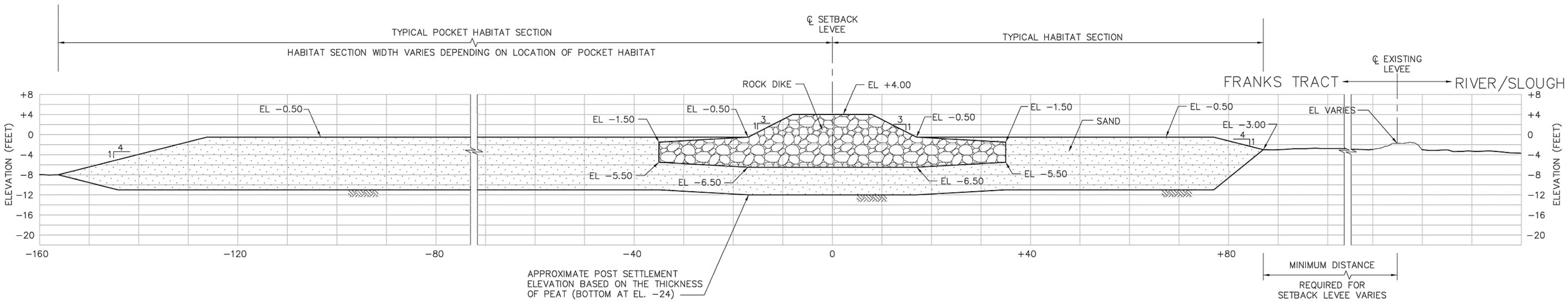
Source: Moffat & Nichol 2005

Typical Habitat/Habitat Levee

EXHIBIT 3.1-1

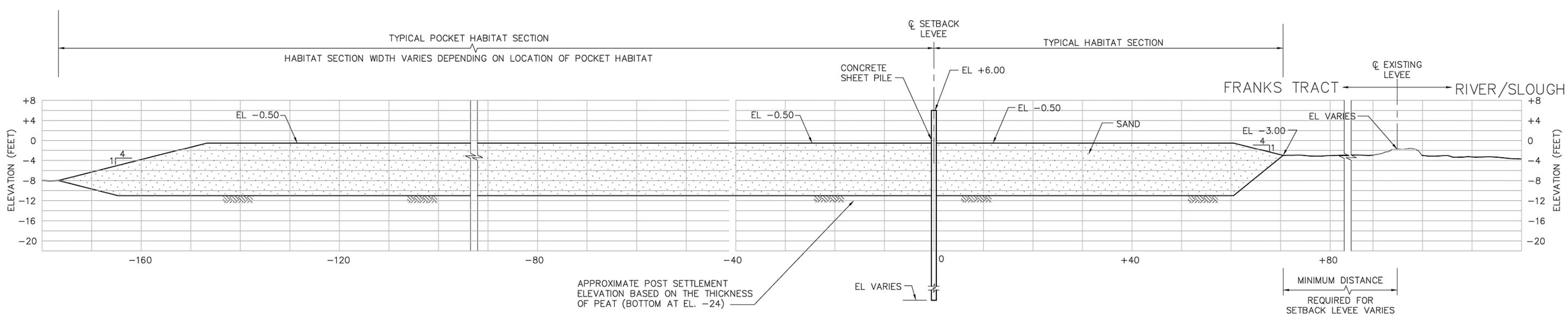
0 11 22 FEET NORTH

EDAW



POCKET HABITAT WITH ROCK DIKE (HABITAT/HABITAT OPTION)

1" = 20'



POCKET HABITAT WITH CONCRETE WALL (HABITAT/HABITAT OPTION)

1" = 20'

NOTE:

ELEVATIONS ARE BASED ON NGVD 1929.

Source: Moffat & Nichol 2005

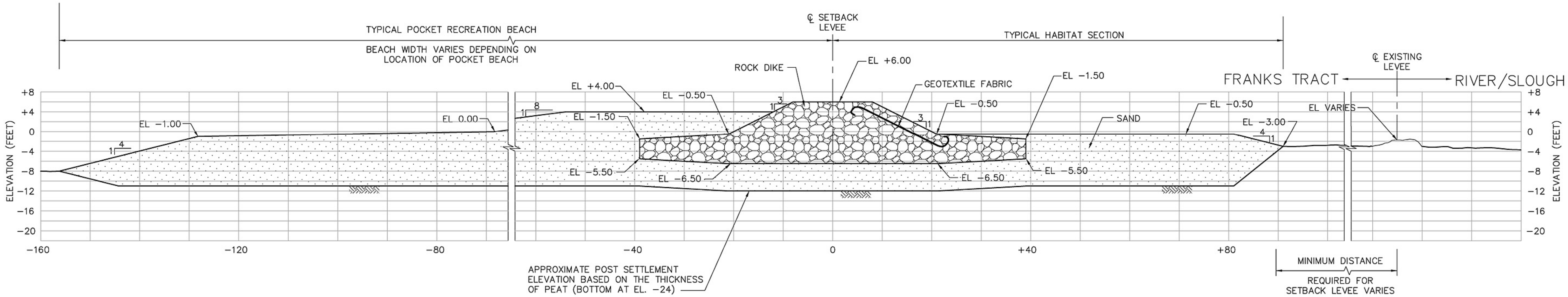
Typical Pocket Habitat

EXHIBIT 3.1-4

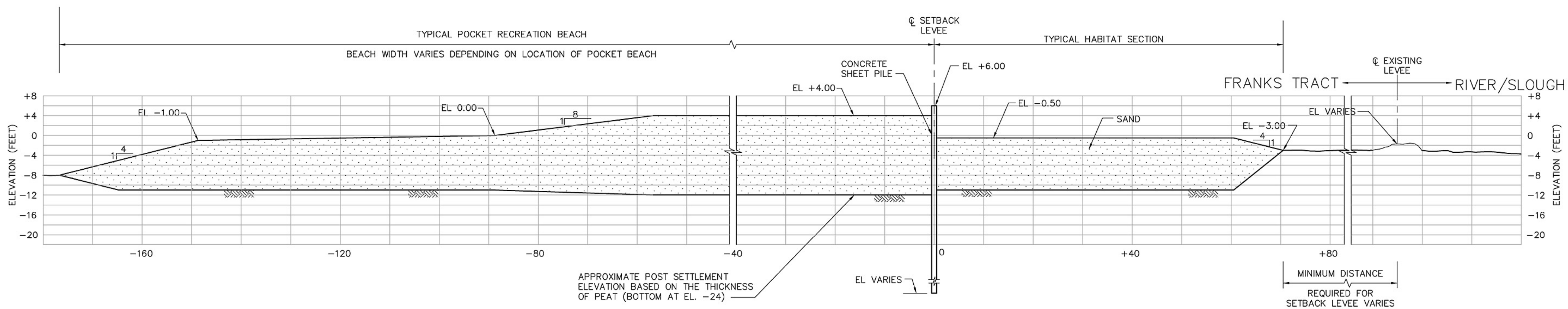
0 11 22 FEET

NORTH

EDAW



POCKET BEACH WITH ROCK DIKE (HABITAT/ BEACH OPTION)



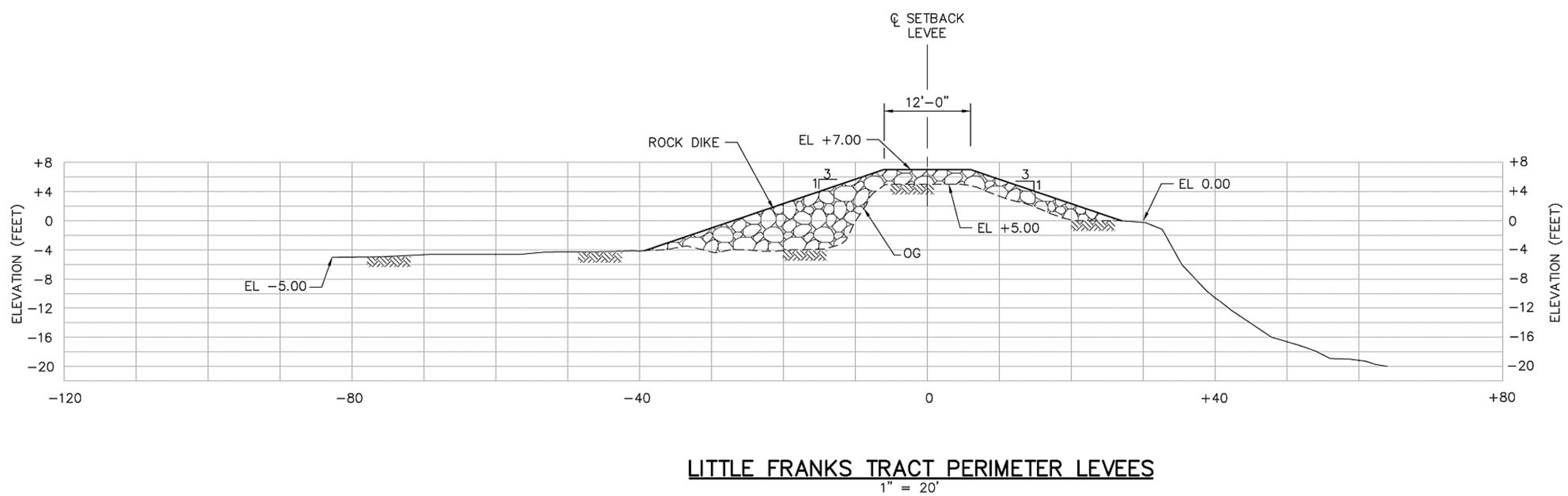
POCKET BEACH WITH CONCRETE WALL (HABITAT/BEACH OPTION)

Source: Moffat & Nichol 2005

Typical Pocket Beach

EXHIBIT 3.1-3

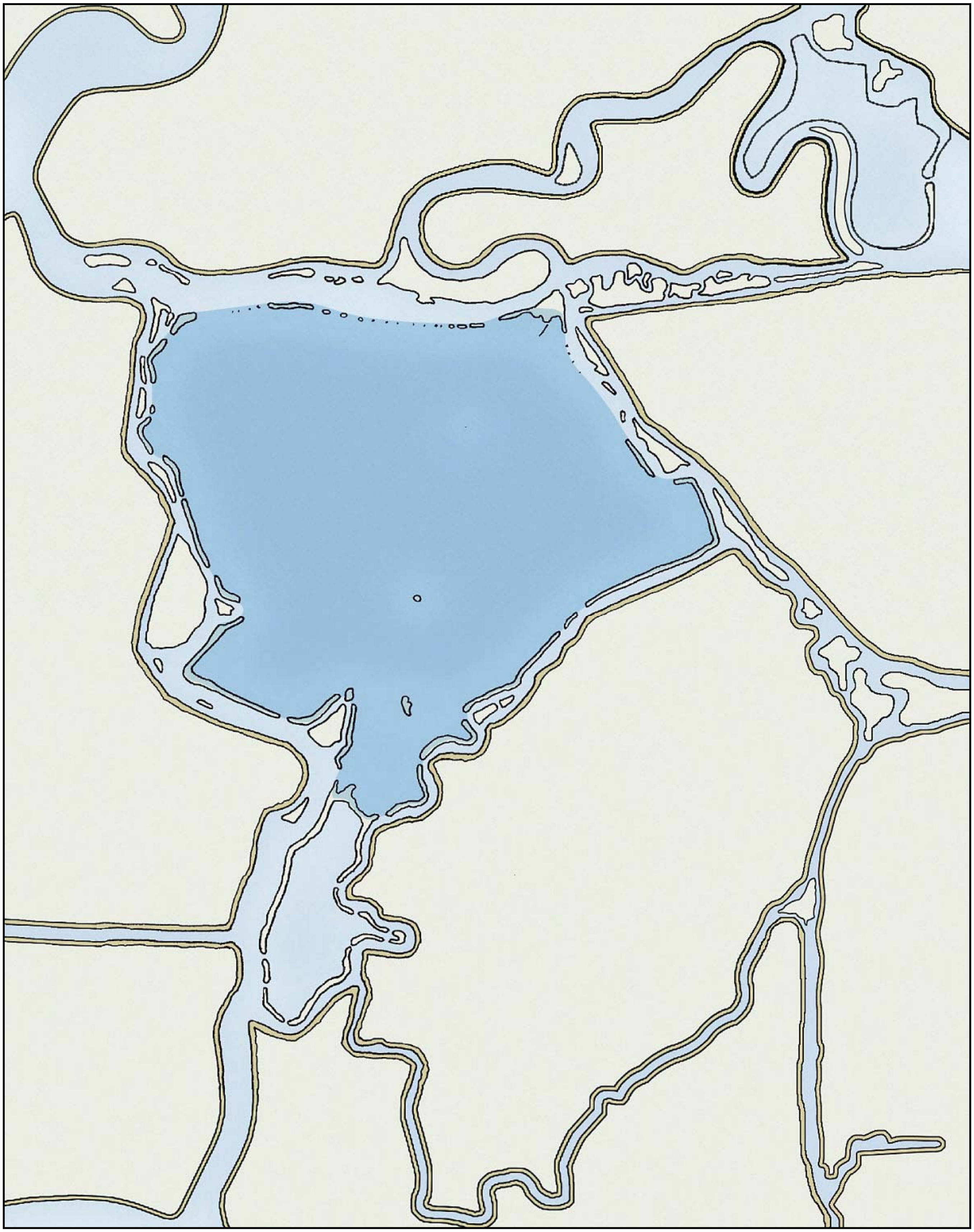
0 11 22
FEET
NORTH
EDAW



Source: Moffat & Nichol 2005

Typical Little Franks Tract Perimeter Levee

EXHIBIT 3.1-5



Source: EDAW 2005

Preliminary Alternative - No Franks Tract

EXHIBIT 3.3-1

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps	⇩	-1%	0%	6%	7%	7%	8%	8%	5%
Reduction in monthly average EC at CVP pumps	⇩	-1%	0%	4%	5%	5%	6%	6%	4%
Reduction in monthly average EC at CCWD Old Riv.	⇩	-2%	-1%	7%	9%	9%	10%	11%	9%
Reduction in monthly average EC at CCWD Rock S.	⇩	-2%	-1%	9%	9%	9%	12%	14%	7%
Fatal Flaws		**Notes**							
Material availablity	no	Approximately 45-90 mcy required to fill Franks Tract							
Residence time in Franks Tract	n/a								
Recreational impacts	⇩	Filling of Franks Tract is a severe impediment to boat passage							

Legend

Fatal flaw

Beneficial change

Neutral change

Detrimental change

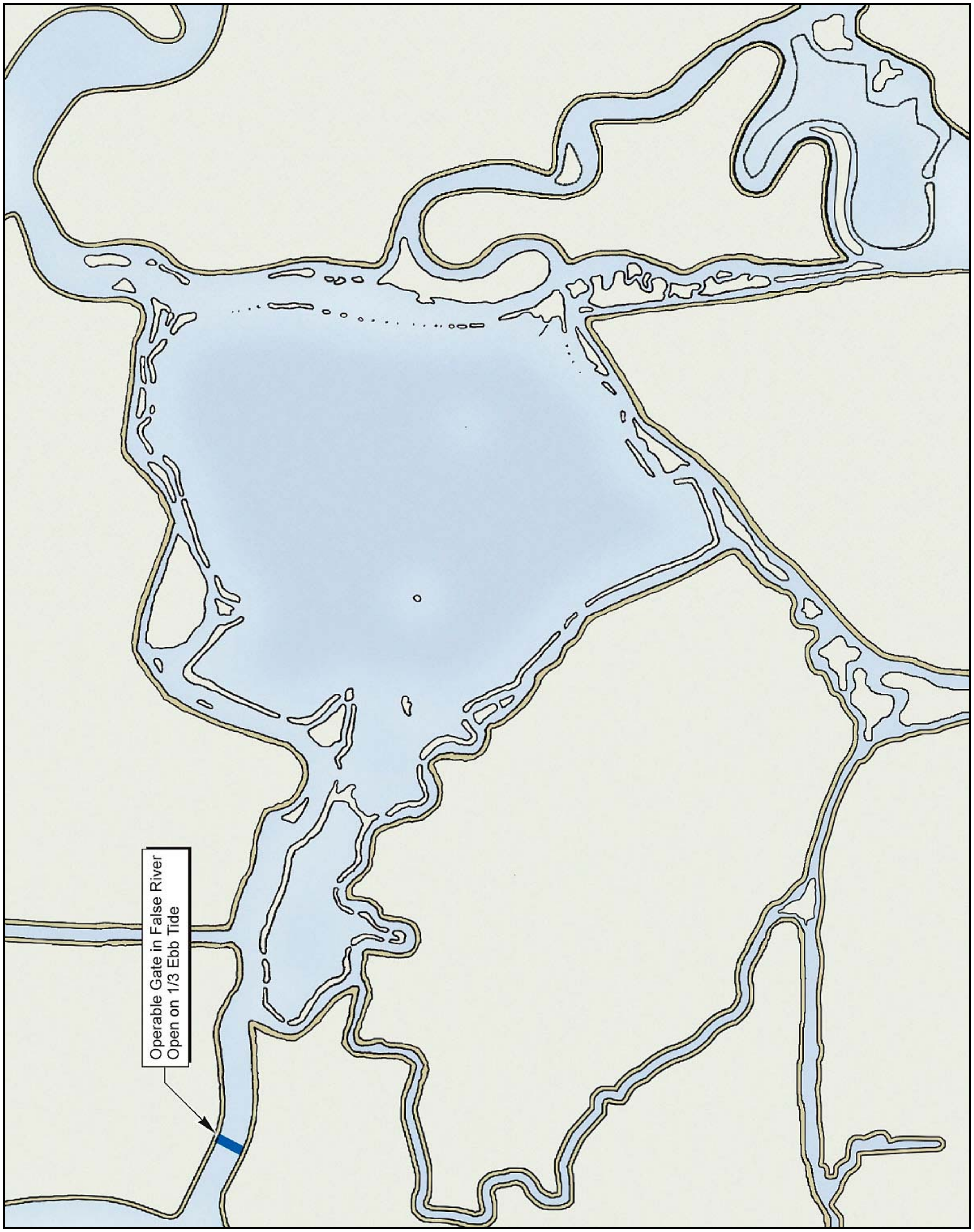
Note: Arrows indicate direction of change.

Arrow width indicates magnitude of change.

Source: NHI 2005

No Franks Tract (Bookend) – Fatal Flaw Matrix

EXHIBIT 3.3-2



Source: EDAW 2005

Preliminary Alternative - West False River Gate

EXHIBIT 3.3-3

EDAW

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	1%	11%	16%	17%	13%	8%	5%
Reduction in monthly average EC at CVP pumps		0%	1%	7%	10%	12%	10%	5%	3%
Reduction in monthly average EC at CCWD Old Riv.		0%	2%	17%	22%	24%	19%	14%	11%
Reduction in monthly average EC at CCWD Rock S.		0%	2%	20%	24%	27%	25%	21%	7%
Fatal Flaws		**Notes**							
Material availablity	yes	Gate option requires little fill material							
Residence time in Franks Tract		Peak modeled residence time = 5 days							
Recreational impacts		Boat passage limited between W. False River and San Joaquin							

Legend

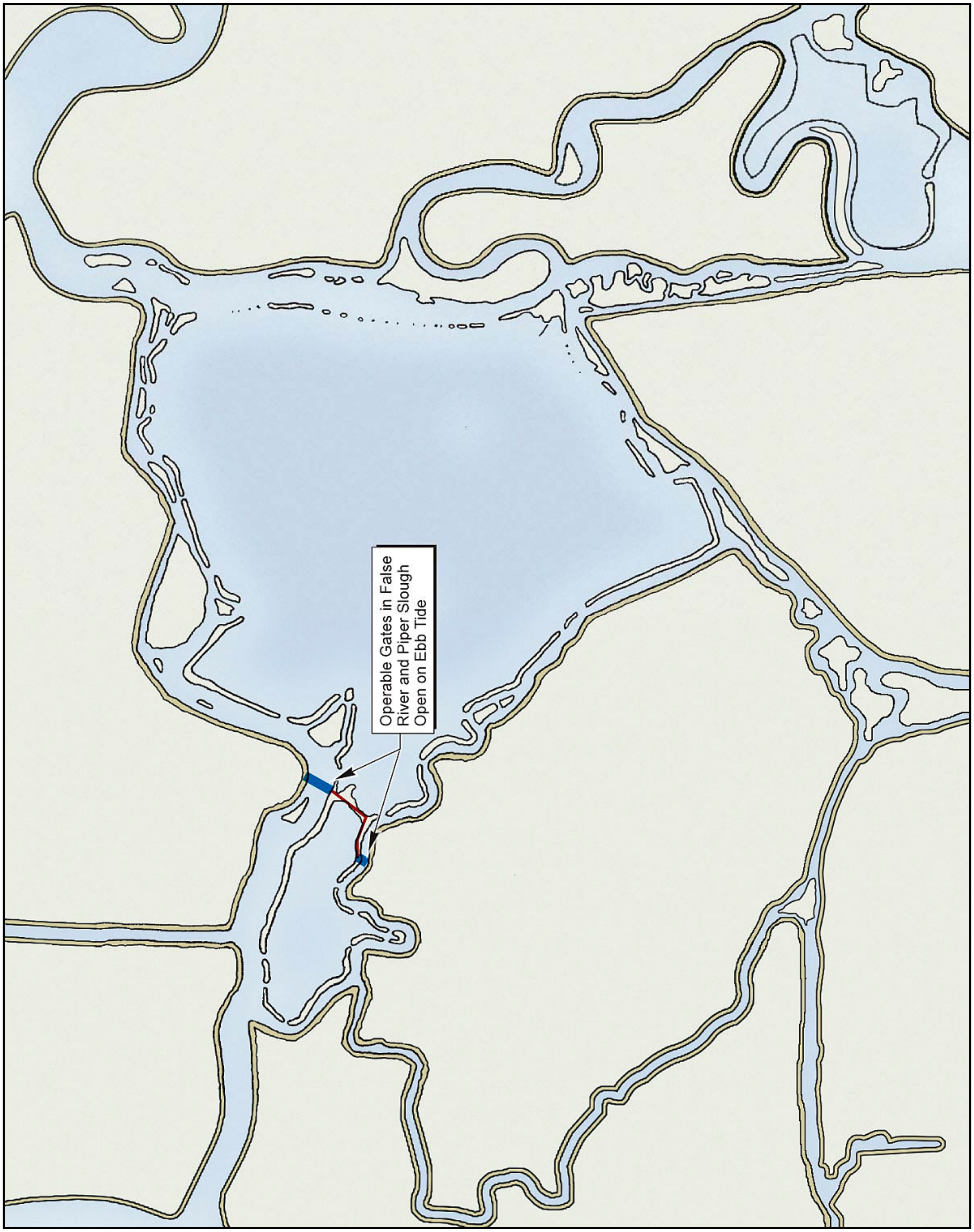
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

West False River Gate – Fatal Flaw Matrix

EXHIBIT 3.3-4



Source: EDAW 2005

Preliminary Alternative - False River and Piper Slough Gates

EXHIBIT 3.3-5

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	0%	4$	14%	11%	3%	-7%	-5%
Reduction in monthly average EC at CVP pumps		0%	0%	2%	8%	7%	1%	-7%	-4%
Reduction in monthly average EC at CCWD Old Riv.		0%	-1%	10%	21%	19%	9%	-3%	-2%
Reduction in monthly average EC at CCWD Rock S.		0%	1%	13%	23%	23%	18%	5%	0%
Fatal Flaws		**Notes**							
Material availablity	yes	Gate option requires little fill material							
Residence time in Franks Tract		Peak modeled residence time = 3 days							
Recreational impacts		Boat passage limited between Franks Tract and San Joaquin							

Legend

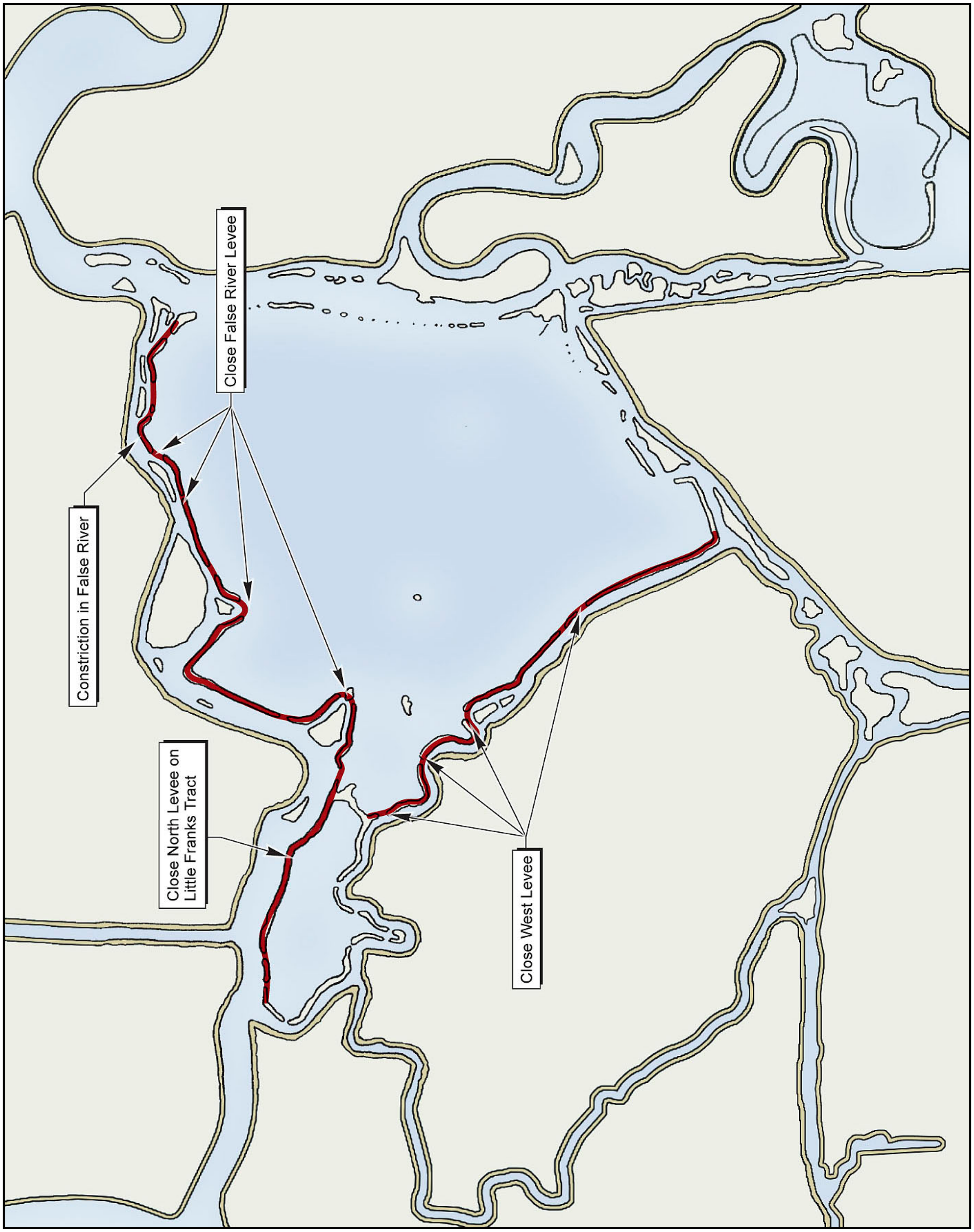
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

False River and Piper Slough Gates – Fatal Flaw Matrix

EXHIBIT 3.3-6



Source: EDAW 2005

Preliminary Alternative - East Side Open

EXHIBIT 3.3-7

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		1%	1%	12%	13%	14%	14%	13%	9%
Reduction in monthly average EC at CVP pumps		0%	0%	7%	8%	10%	11%	9%	6%
Reduction in monthly average EC at CCWD Old Riv.		0%	1%	17%	18%	20%	19%	19%	14%
Reduction in monthly average EC at CCWD Rock S.		1%	1%	20%	21%	22%	23%	25%	12%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract		Peak modeled residence time = 12 days							
Recreational impacts		Blocks boat passage through Piper Slough and False River levees; potential for beaches on levees							

Legend

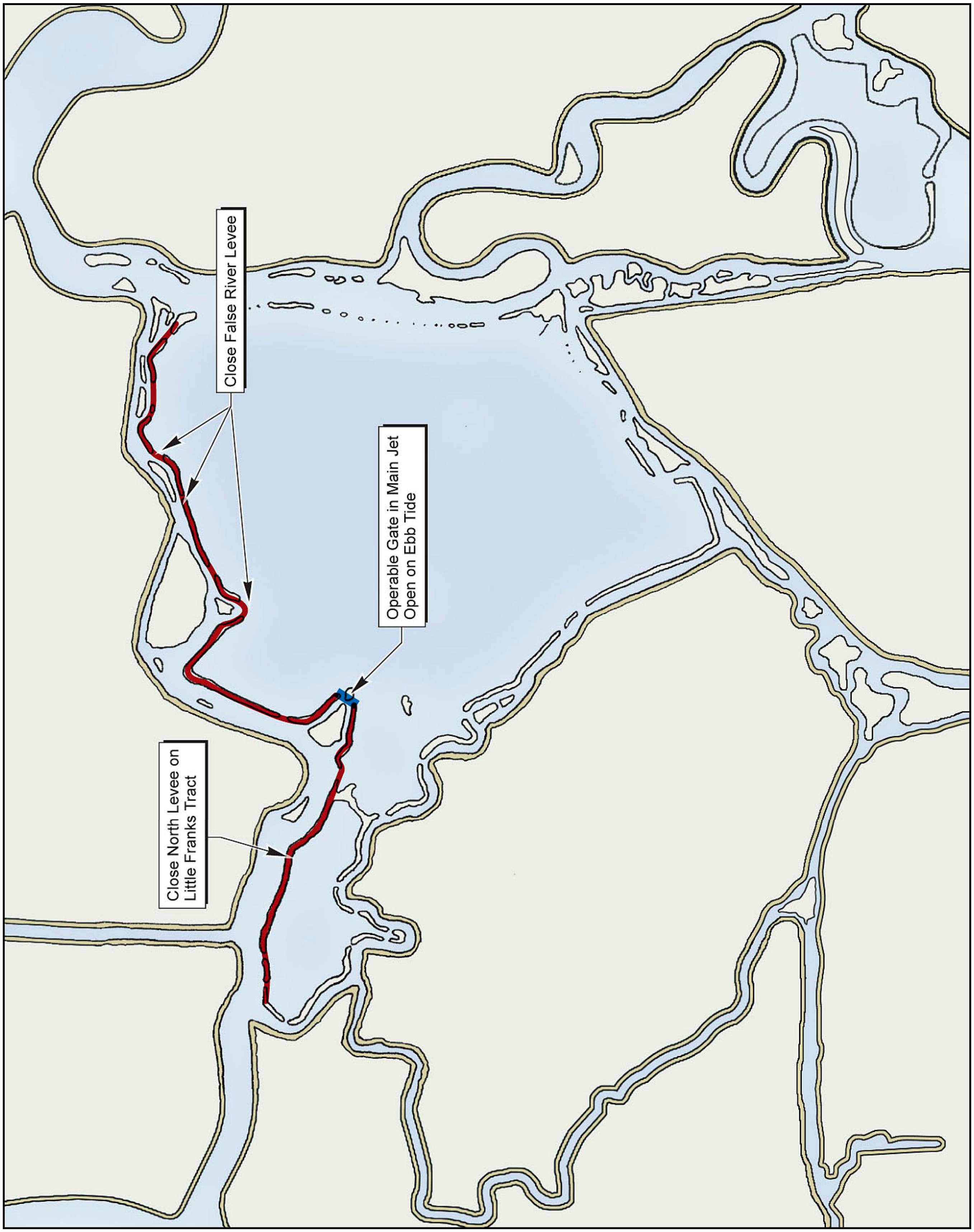
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

East Side Open – Fatal Flaw Matrix

EXHIBIT 3.3-8



Source: EDAW 2005

Preliminary Alternative - North Levee and Nozzle Gate

EXHIBIT 3.3-9

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps	⇩	0%	1%	3%	4%	3%	2%	-1%	-1%
Reduction in monthly average EC at CVP pumps	⇩	0%	0%	1%	1%	1%	0%	-2%	-1%
Reduction in monthly average EC at CCWD Old Riv.	⇩	0%	1%	7%	8%	9%	6%	3%	2%
Reduction in monthly average EC at CCWD Rock S.	⇩	0%	1%	10%	11%	12%	11%	8%	2%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract	⇧	Peak modeled residence time = 3 days							
Recreational impacts	⇧	Blocks boat passage through False River levee; potential for beaches on levees							

Legend

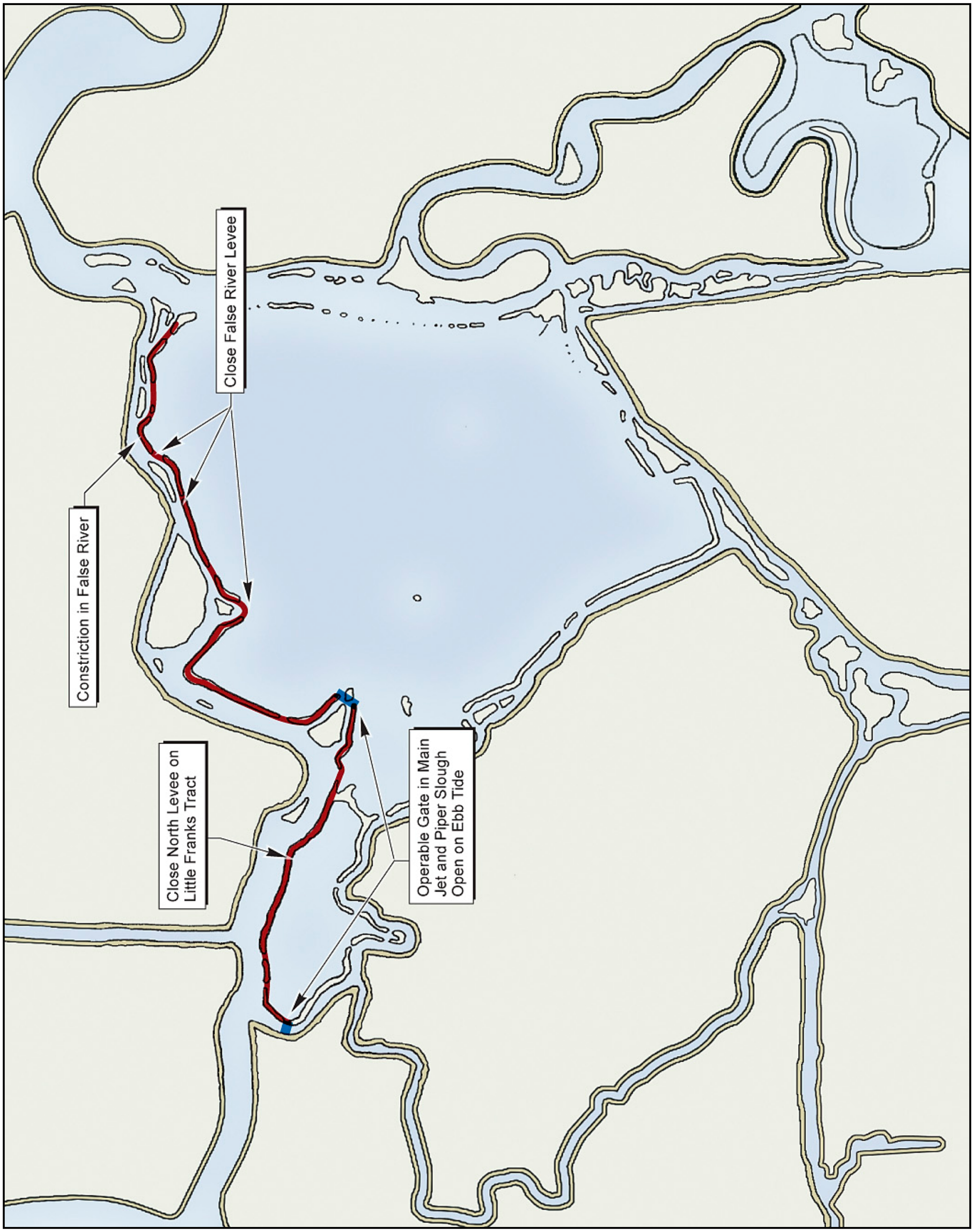
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

North Levee and Nozzle Gate – Fatal Flaw Matrix

EXHIBIT 3.3-10



Source: EDAW 2005

Preliminary Alternative -
North Levee, Nozzle Gate, and Piper Slough Gate

EXHIBIT 3.3-11

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps	⇩	0%	0%	4%	10%	8%	2%	-6%	-4%
Reduction in monthly average EC at CVP pumps	⇩	0%	0%	1%	5%	4%	0%	-6%	-4%
Reduction in monthly average EC at CCWD Old Riv.	⇩	0%	0%	9%	17%	16%	8%	0%	-1%
Reduction in monthly average EC at CCWD Rock S.	⇩	0%	1%	13%	21%	21%	17%	7%	1%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract	⇧	Peak modeled residence time = 3 days							
Recreational impacts	⇧	Blocks boat passage through False River levee; potential for beaches on levees							

Legend

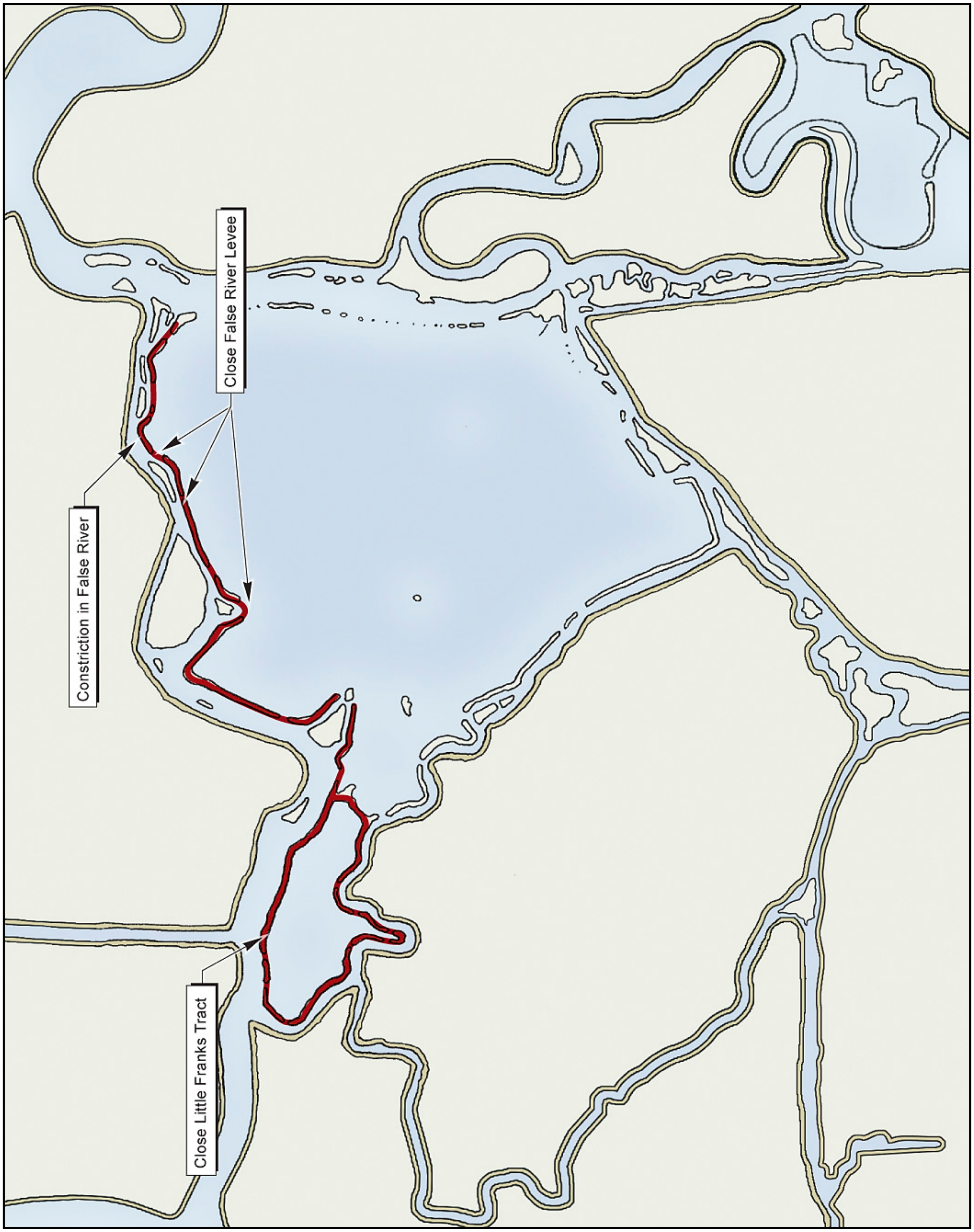
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

Nozzle Gate and Piper Slough Gate – Fatal Flaw Matrix

EXHIBIT 3.3-12



Source: EDAW 2005

Preliminary Alternative -
North Levee and Close Little Franks Tract

EXHIBIT 3.3-13

EDAW

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps	⇩	0%	0%	6%	5%	6%	6%	7%	5%
Reduction in monthly average EC at CVP pumps	⇩	0%	0%	4%	3%	5%	5%	5%	3%
Reduction in monthly average EC at CCWD Old Riv.	⇩	-1%	0%	9%	8%	9%	9%	10%	8%
Reduction in monthly average EC at CCWD Rock S.	⇩	-1%	0%	11%	9%	10%	11%	13%	5%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract	⇧	Peak modeled residence time = 6 days							
Recreational impacts	⇧	Blocks boat passage through False River levee; potential for beaches on levees							

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

North Levee and Close Little Franks Tract- Fatal Flaw Matrix

EXHIBIT 3.3-14

Source: EDAW 2005

Preliminary Alternative - East Levee and Gates

EXHIBIT 3.3-15

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	8%	12%	16%	17%	20%	16%	9%
Reduction in monthly average EC at CVP pumps		0%	7%	7%	10%	12%	15%	11%	6%
Reduction in monthly average EC at CCWD Old Riv.		0%	7%	18%	23%	24%	27%	24%	17%
Reduction in monthly average EC at CCWD Rock S.		0%	8%	22%	26%	28%	32%	30%	17%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract		Peak modeled residence time = 12 days							
Recreational impacts		Blocks boat passage from Old River to Franks Tract; potential for beaches on levees							

Legend

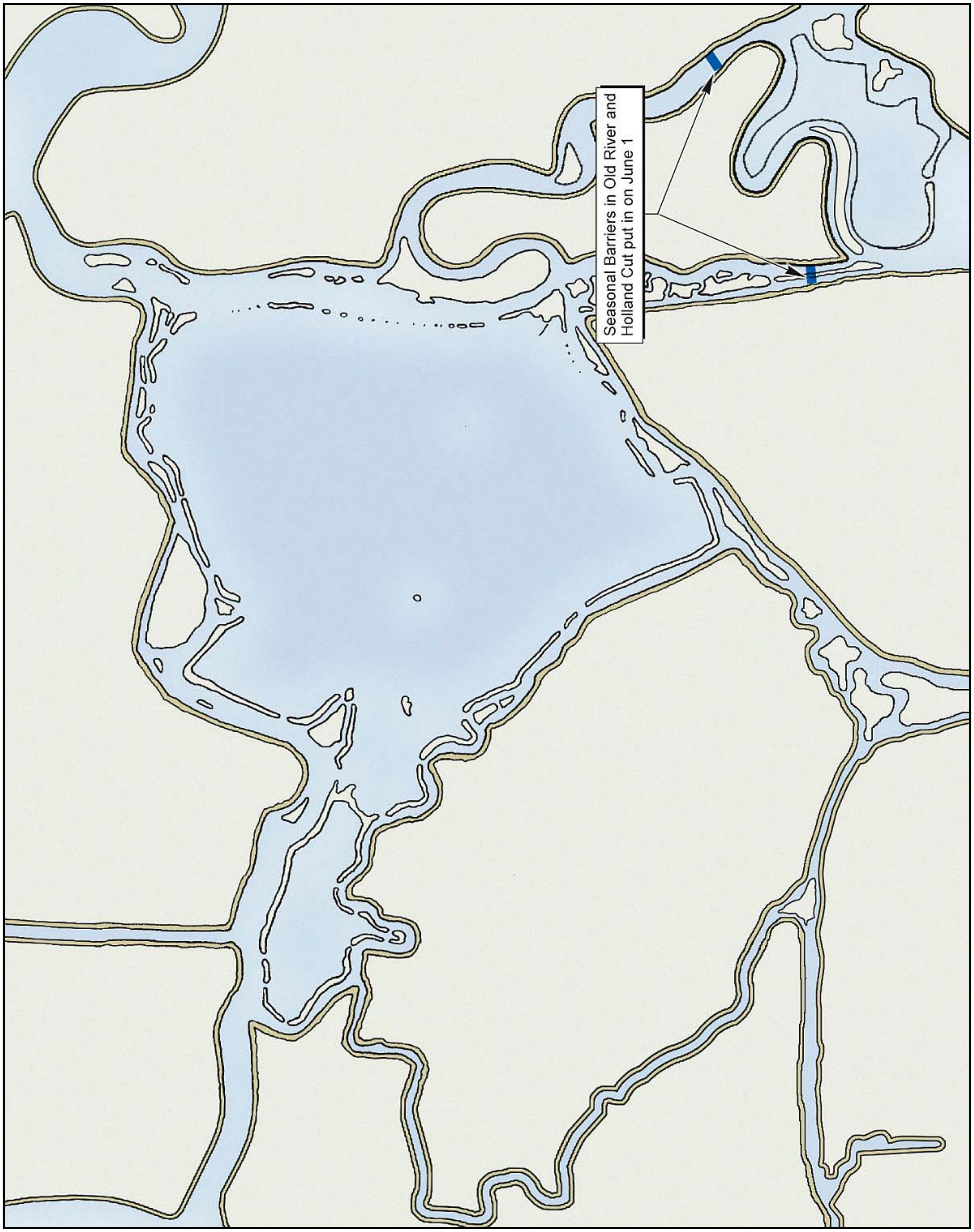
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

East Levee and Gates – Fatal Flaw Matrix

EXHIBIT 3.3-16



Source: EDAW 2005

Preliminary Alternative - Cox Alternative

EXHIBIT 3.3-17

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	1%	12%	12%	11%	10%	9%	5%
Reduction in monthly average EC at CVP pumps		0%	0%	6%	5%	6%	7%	7%	3%
Reduction in monthly average EC at CCWD Old Riv.		0%	-1%	18%	20%	20%	18%	15%	10%
Reduction in monthly average EC at CCWD Rock S.		0%	0%	23%	25%	25%	25%	21%	14%
Fatal Flaws		**Notes**							
Material availablity	yes	Gate option requires little fill material							
Residence time in Franks Tract		Peak modeled residence time = 8 days							
Recreational impacts		Blocks boat passage from southern Old River							

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

Cox Alternative – Fatal Flaw Matrix

EXHIBIT 3.3-18

Class	Isolation	West Gates		North Levees				East Levees	East Gates
Alternative	No Franks Tract	West False River Gate	False River and Piper Gates	East Side Open	N. Levee and Nozzle Gate	Nozzle Gate and Piper Gate	N. Levee and Close Little Franks Tract	East Levee and Gates	Cox Alternative
Impact on Salinity									
Reduction in monthly average EC at SWP pumps	↓	↓	↓	↓	↓	↓	↓	↓	↓
Reduction in monthly average EC at CVP pumps	↓	↓	↓	↓	↓	↓	↓	↓	↓
Reduction in monthly average EC at CCWD Old Riv.	↓	↓	↓	↓	↓	↓	↓	↓	↓
Reduction in monthly average EC at CCWD Rock S.	↓	↓	↓	↓	↓	↓	↓	↓	↓
Fatal Flaws									
Material availablity	no	yes	yes	yes	yes	yes	yes	yes	yes
Residence time in Franks Tract	n/a	↓	↓	↑	↑	↓	↑	↑	↑
Recreational impacts	↓	↓	↓	↓	↑	↑	↑	↓	↓

Legend

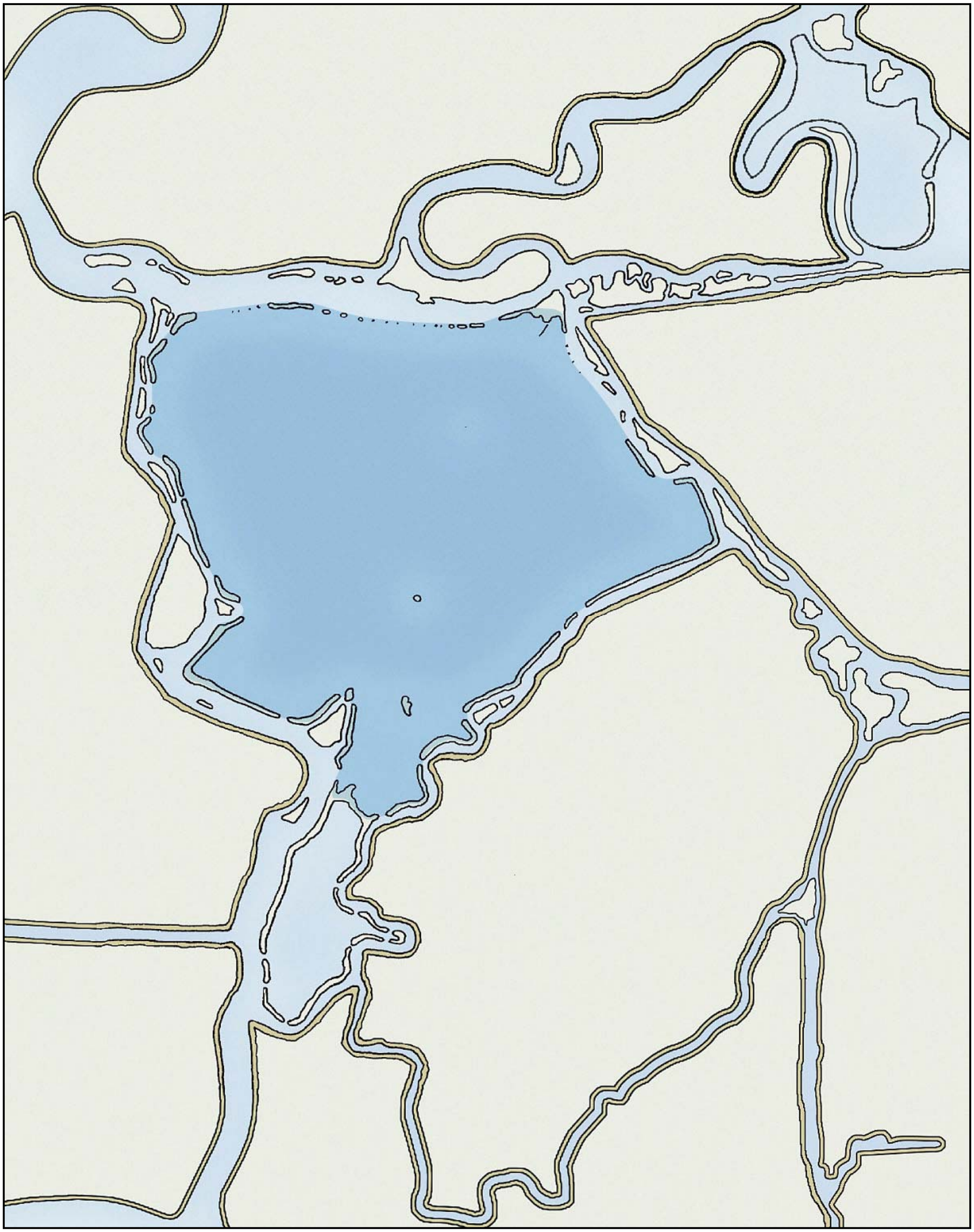
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

Preliminary Alternatives
Summary Comparison Fatal Flaw Screening Matrix

EXHIBIT 3.3-19



Source: EDAW 2005

Preliminary Alternative - No Franks Tract

EXHIBIT 3.3-1

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps	↓	-1%	0%	6%	7%	7%	8%	8%	5%
Reduction in monthly average EC at CVP pumps	↓	-1%	0%	4%	5%	5%	6%	6%	4%
Reduction in monthly average EC at CCWD Old Riv.	↓	-2%	-1%	7%	9%	9%	10%	11%	9%
Reduction in monthly average EC at CCWD Rock S.	↓	-2%	-1%	9%	9%	9%	12%	14%	7%
Fatal Flaws		**Notes**							
Material availablity	no	Approximately 45-90 mcy required to fill Franks Tract							
Residence time in Franks Tract	n/a								
Recreational impacts	↓	Filling of Franks Tract is a severe impediment to boat passage							

Legend

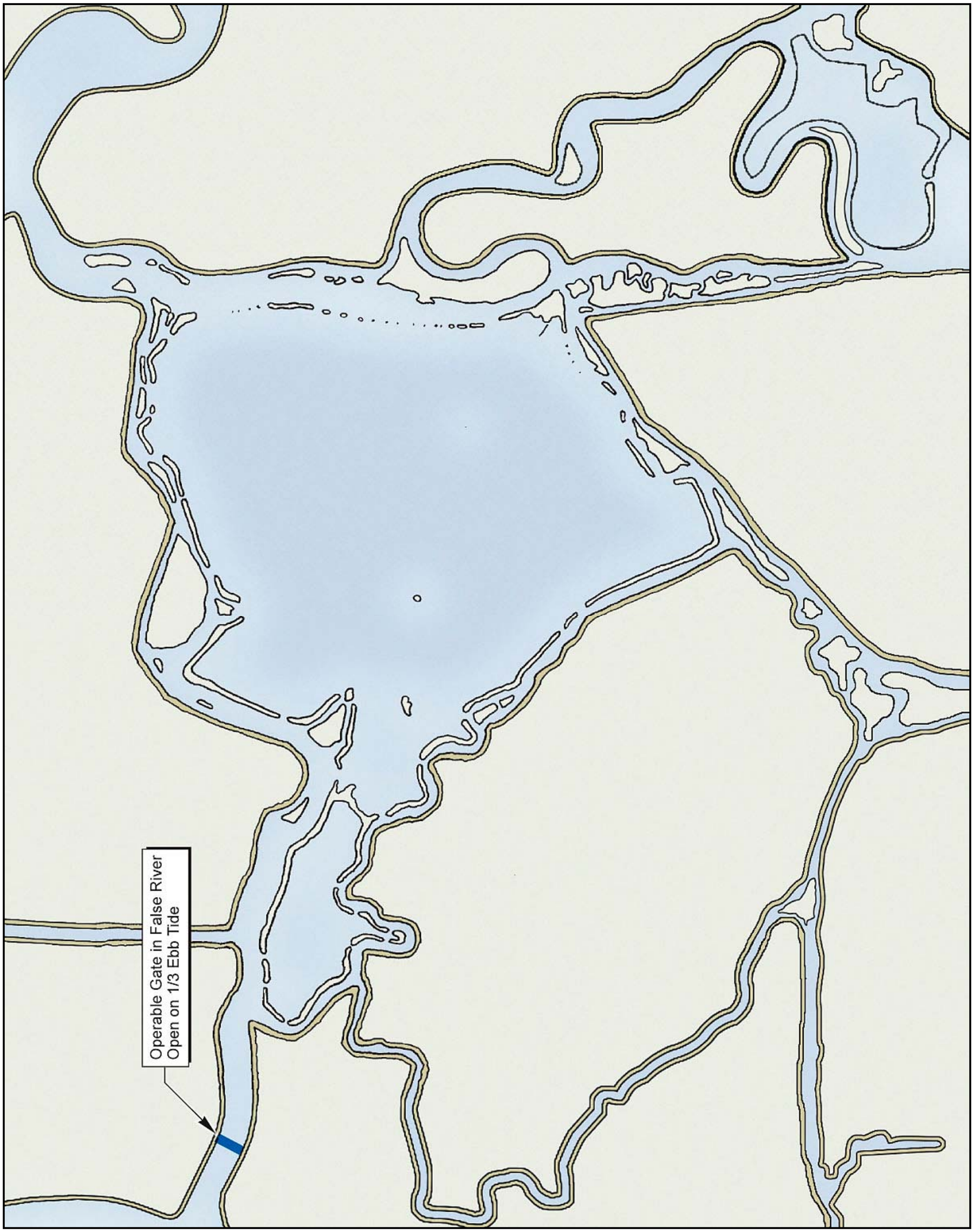
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

No Franks Tract (Bookend) – Fatal Flaw Matrix

EXHIBIT 3.3-2



Source: EDAW 2005

Preliminary Alternative - West False River Gate

EXHIBIT 3.3-3

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	1%	11%	16%	17%	13%	8%	5%
Reduction in monthly average EC at CVP pumps		0%	1%	7%	10%	12%	10%	5%	3%
Reduction in monthly average EC at CCWD Old Riv.		0%	2%	17%	22%	24%	19%	14%	11%
Reduction in monthly average EC at CCWD Rock S.		0%	2%	20%	24%	27%	25%	21%	7%
Fatal Flaws		**Notes**							
Material availablity	yes	Gate option requires little fill material							
Residence time in Franks Tract		Peak modeled residence time = 5 days							
Recreational impacts		Boat passage limited between W. False River and San Joaquin							

Legend

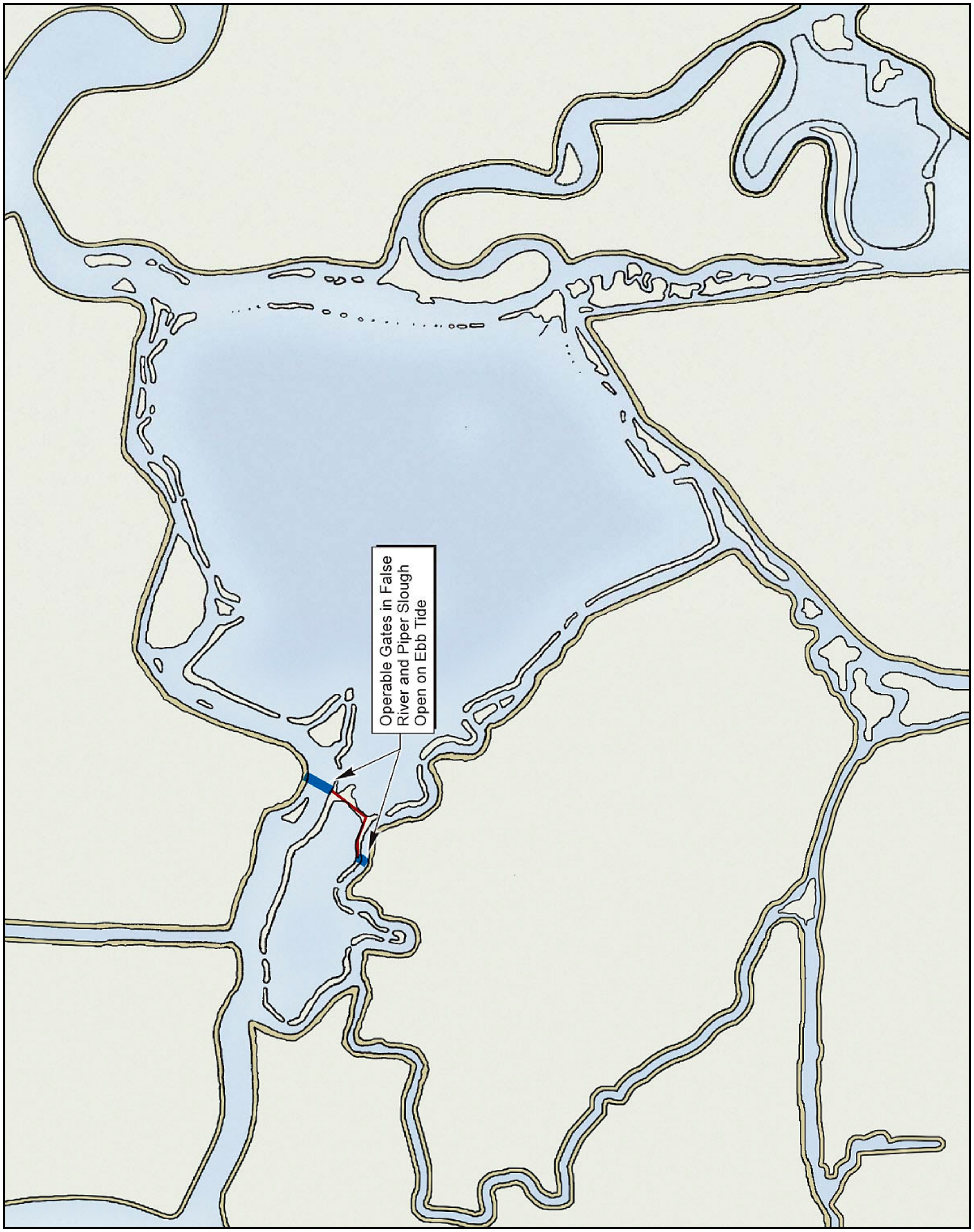
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

West False River Gate – Fatal Flaw Matrix

EXHIBIT 3.3-4



Source: EDAW 2005

Preliminary Alternative - False River and Piper Slough Gates

EXHIBIT 3.3-5

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	0%	4$	14%	11%	3%	-7%	-5%
Reduction in monthly average EC at CVP pumps		0%	0%	2%	8%	7%	1%	-7%	-4%
Reduction in monthly average EC at CCWD Old Riv.		0%	-1%	10%	21%	19%	9%	-3%	-2%
Reduction in monthly average EC at CCWD Rock S.		0%	1%	13%	23%	23%	18%	5%	0%
Fatal Flaws		**Notes**							
Material availablity	yes	Gate option requires little fill material							
Residence time in Franks Tract		Peak modeled residence time = 3 days							
Recreational impacts		Boat passage limited between Franks Tract and San Joaquin							

Legend

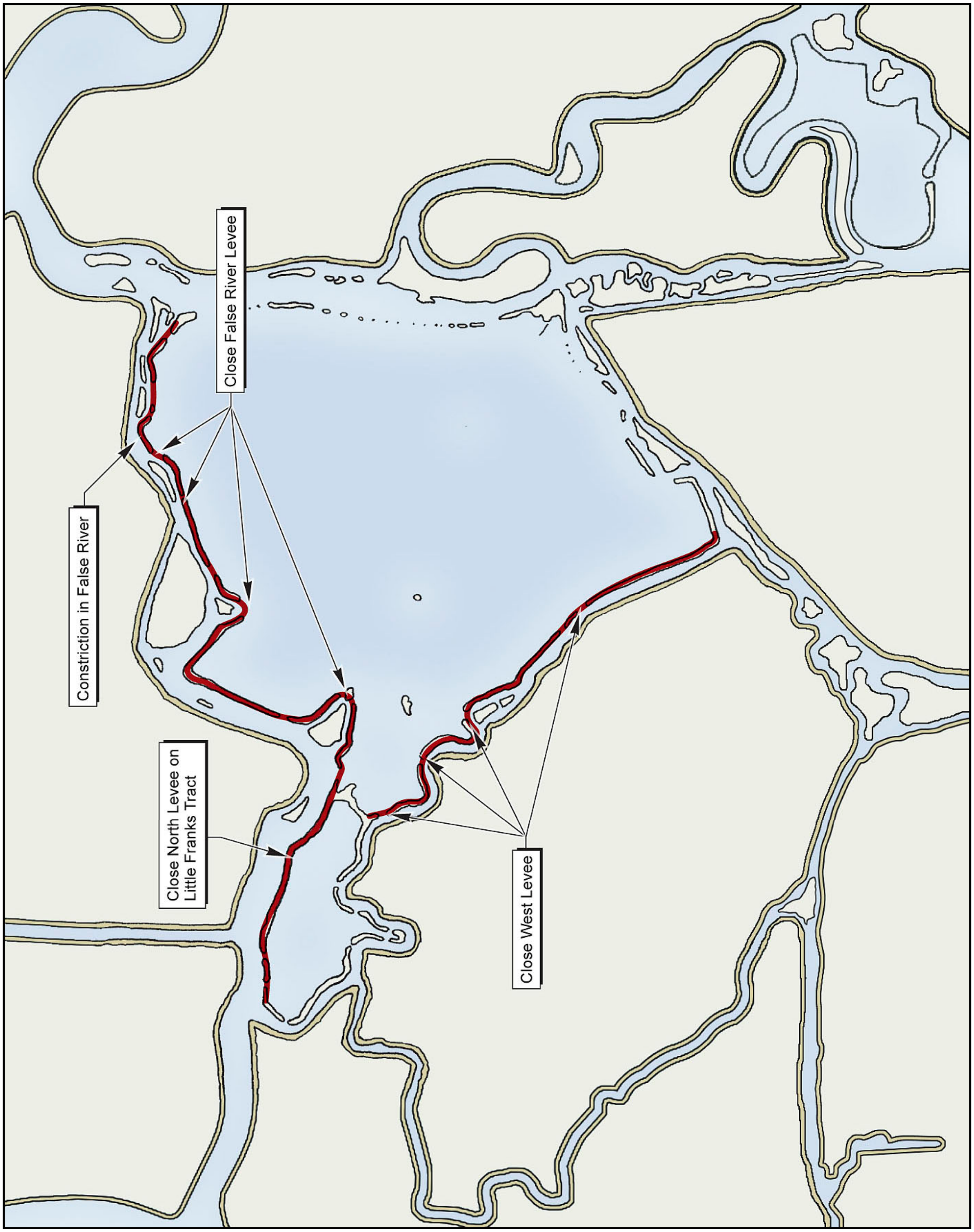
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

False River and Piper Slough Gates – Fatal Flaw Matrix

EXHIBIT 3.3-6



Source: EDAW 2005

Preliminary Alternative - East Side Open

EXHIBIT 3.3-7

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		1%	1%	12%	13%	14%	14%	13%	9%
Reduction in monthly average EC at CVP pumps		0%	0%	7%	8%	10%	11%	9%	6%
Reduction in monthly average EC at CCWD Old Riv.		0%	1%	17%	18%	20%	19%	19%	14%
Reduction in monthly average EC at CCWD Rock S.		1%	1%	20%	21%	22%	23%	25%	12%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract		Peak modeled residence time = 12 days							
Recreational impacts		Blocks boat passage through Piper Slough and False River levees; potential for beaches on levees							

Legend

Fatal flaw

Beneficial change

Neutral change

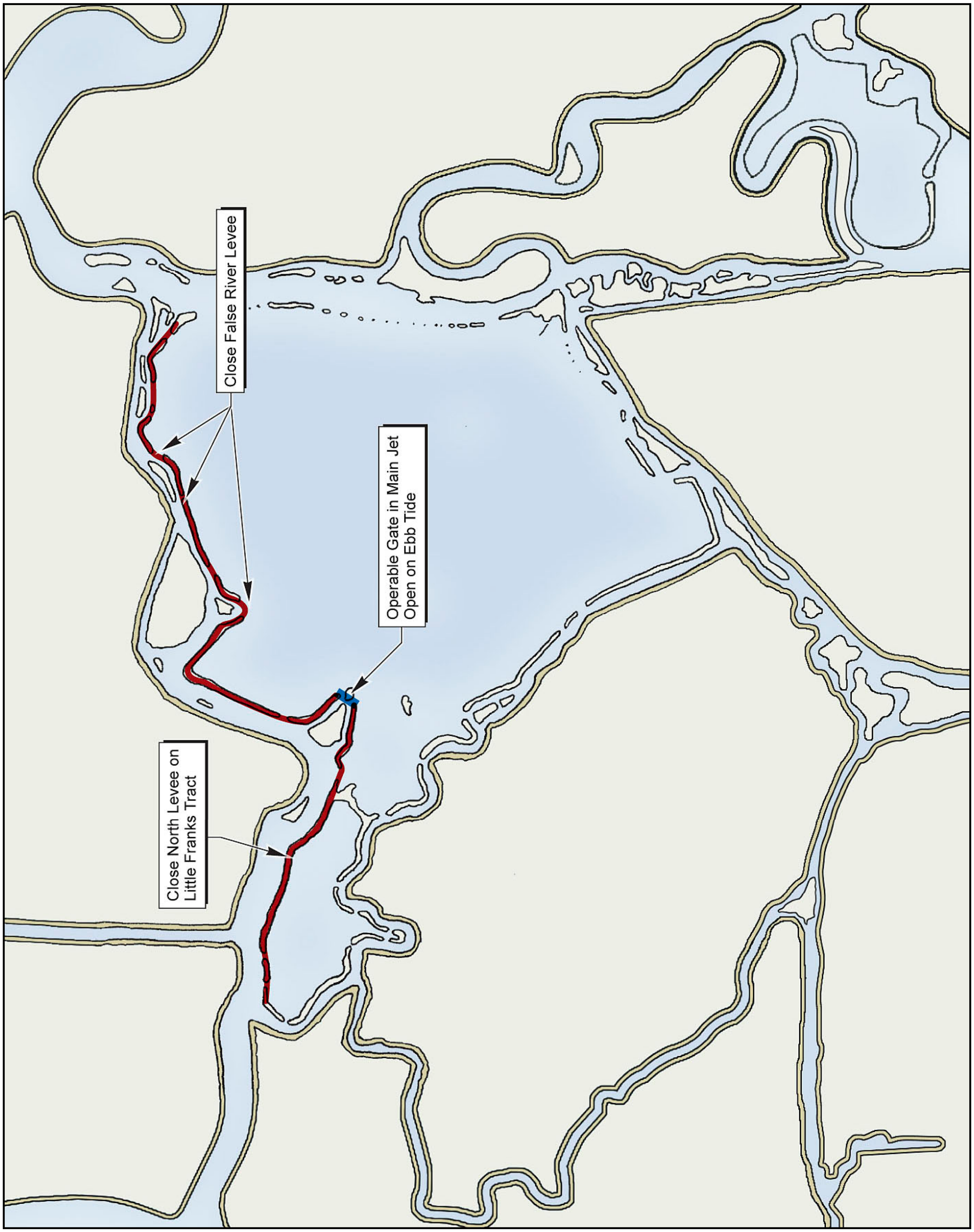
Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

East Side Open – Fatal Flaw Matrix

EXHIBIT 3.3-8



Source: EDAW 2005

Preliminary Alternative - North Levee and Nozzle Gate

EXHIBIT 3.3-9

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps	↓	0%	1%	3%	4%	3%	2%	-1%	-1%
Reduction in monthly average EC at CVP pumps	↓	0%	0%	1%	1%	1%	0%	-2%	-1%
Reduction in monthly average EC at CCWD Old Riv.	↓	0%	1%	7%	8%	9%	6%	3%	2%
Reduction in monthly average EC at CCWD Rock S.	↓	0%	1%	10%	11%	12%	11%	8%	2%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract	↑	Peak modeled residence time = 3 days							
Recreational impacts	↑	Blocks boat passage through False River levee; potential for beaches on levees							

Legend

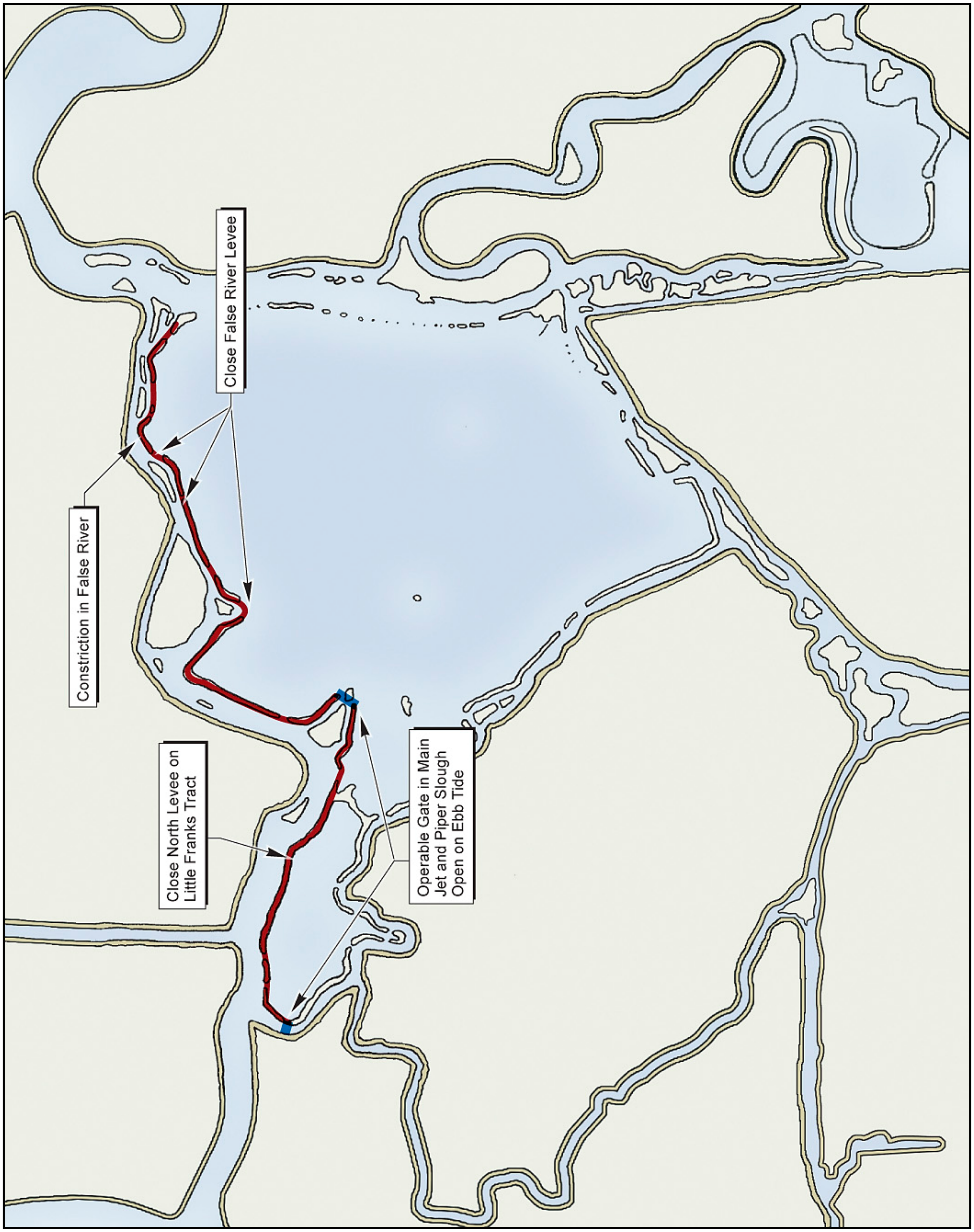
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

North Levee and Nozzle Gate – Fatal Flaw Matrix

EXHIBIT 3.3-10



Source: EDAW 2005

Preliminary Alternative -
North Levee, Nozzle Gate, and Piper Slough Gate

EXHIBIT 3.3-11

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	0%	4%	10%	8%	2%	-6%	-4%
Reduction in monthly average EC at CVP pumps		0%	0%	1%	5%	4%	0%	-6%	-4%
Reduction in monthly average EC at CCWD Old Riv.		0%	0%	9%	17%	16%	8%	0%	-1%
Reduction in monthly average EC at CCWD Rock S.		0%	1%	13%	21%	21%	17%	7%	1%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract		Peak modeled residence time = 3 days							
Recreational impacts		Blocks boat passage through False River levee; potential for beaches on levees							

Legend

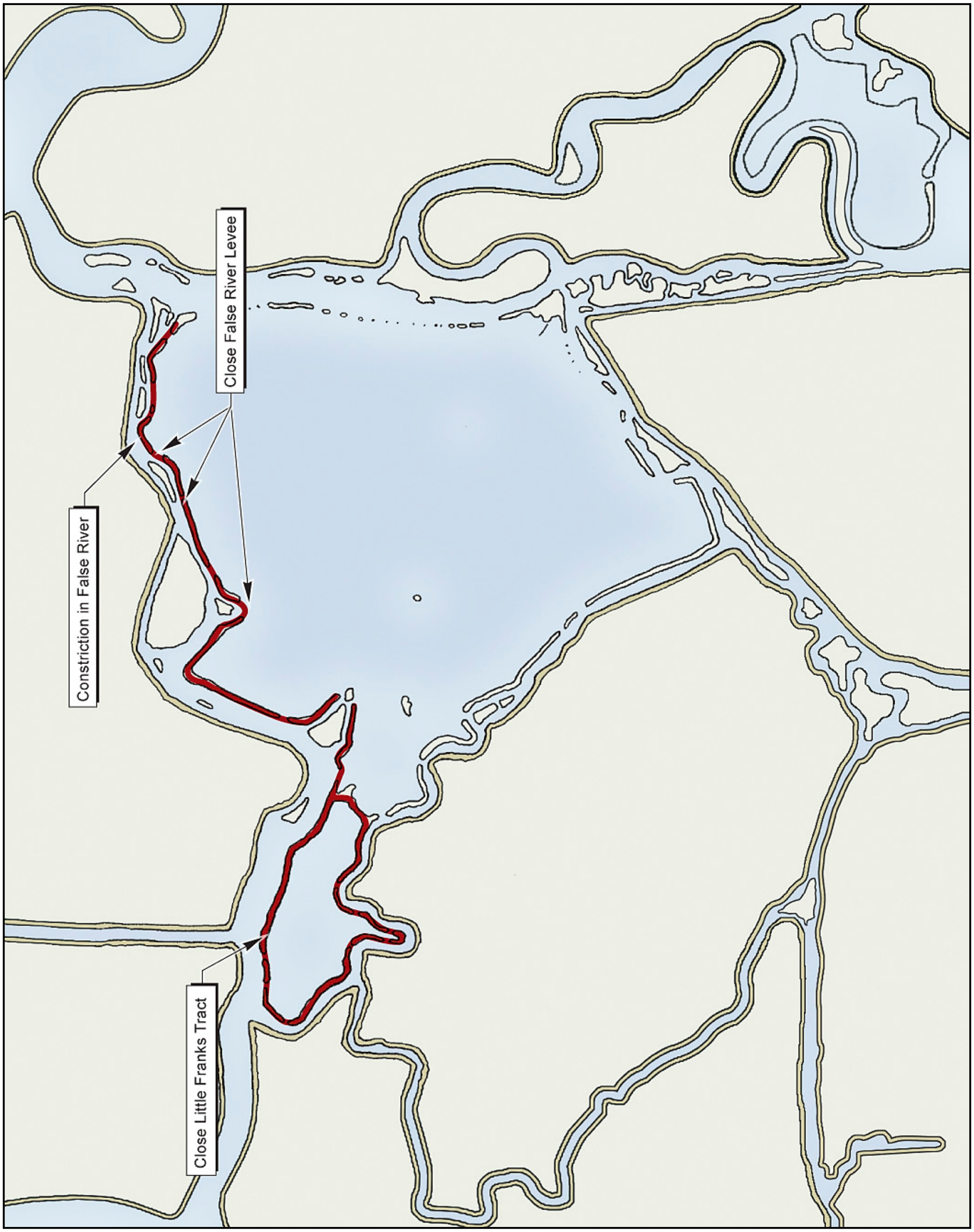
- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

Nozzle Gate and Piper Slough Gate – Fatal Flaw Matrix

EXHIBIT 3.3-12



Source: EDAW 2005

Preliminary Alternative -
North Levee and Close Little Franks Tract

EXHIBIT 3.3-13

EDAW

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps	⇩	0%	0%	6%	5%	6%	6%	7%	5%
Reduction in monthly average EC at CVP pumps	⇩	0%	0%	4%	3%	5%	5%	5%	3%
Reduction in monthly average EC at CCWD Old Riv.	⇩	-1%	0%	9%	8%	9%	9%	10%	8%
Reduction in monthly average EC at CCWD Rock S.	⇩	-1%	0%	11%	9%	10%	11%	13%	5%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract	⇧	Peak modeled residence time = 6 days							
Recreational impacts	⇧	Blocks boat passage through False River levee; potential for beaches on levees							

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

North Levee and Close Little Franks Tract- Fatal Flaw Matrix

EXHIBIT 3.3-14

Source: EDAW 2005

Preliminary Alternative - East Levee and Gates

EXHIBIT 3.3-15

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	8%	12%	16%	17%	20%	16%	9%
Reduction in monthly average EC at CVP pumps		0%	7%	7%	10%	12%	15%	11%	6%
Reduction in monthly average EC at CCWD Old Riv.		0%	7%	18%	23%	24%	27%	24%	17%
Reduction in monthly average EC at CCWD Rock S.		0%	8%	22%	26%	28%	32%	30%	17%
Fatal Flaws		**Notes**							
Material availablity	yes								
Residence time in Franks Tract		Peak modeled residence time = 12 days							
Recreational impacts		Blocks boat passage from Old River to Franks Tract; potential for beaches on levees							

Legend

Fatal flaw

Beneficial change

Neutral change

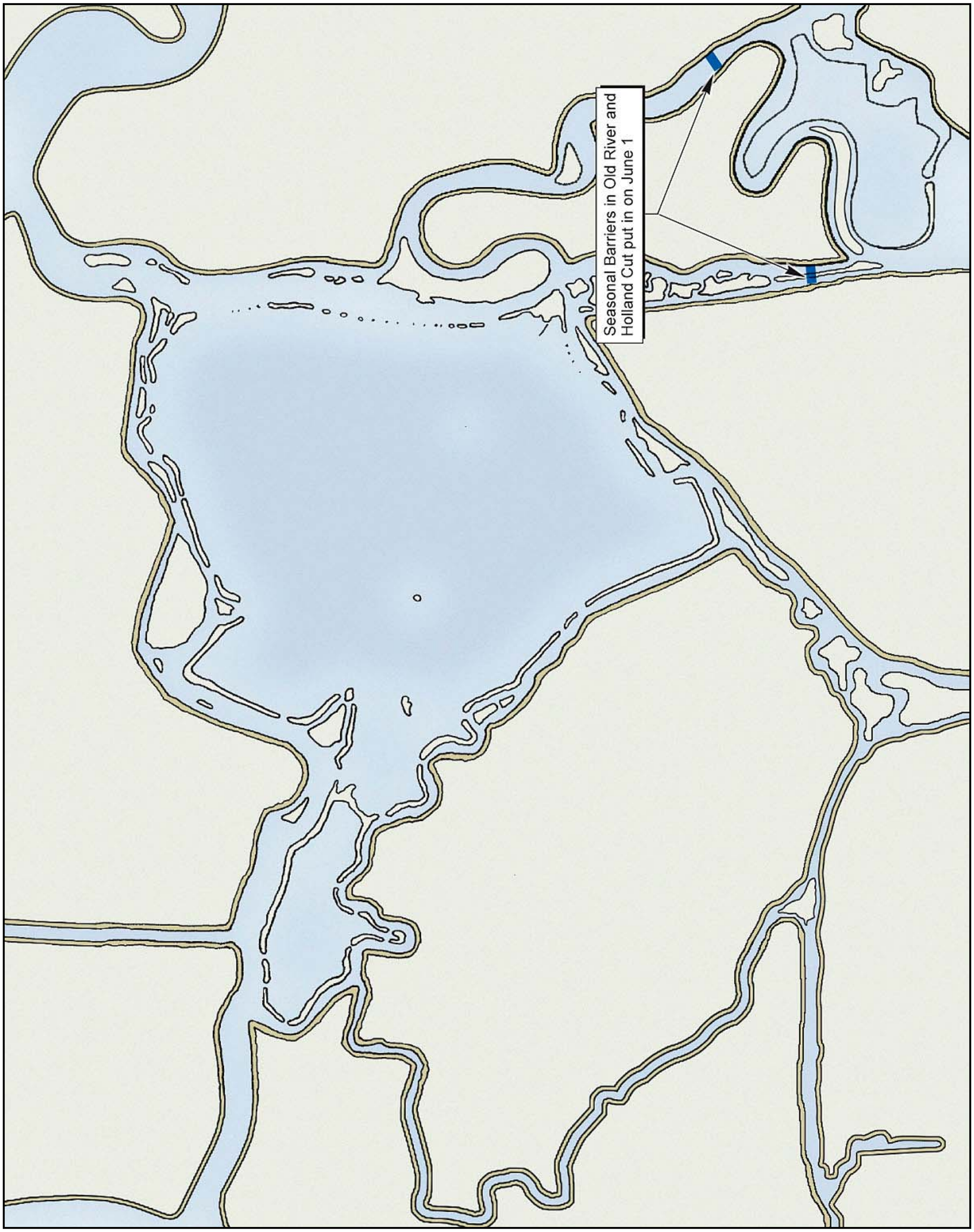
Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

East Levee and Gates – Fatal Flaw Matrix

EXHIBIT 3.3-16



Source: EDAW 2005

Preliminary Alternative - Cox Alternative

EXHIBIT 3.3-17

EDAW

Criteria	Assesment								
Impact on Salinity		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in monthly average EC at SWP pumps		0%	1%	12%	12%	11%	10%	9%	5%
Reduction in monthly average EC at CVP pumps		0%	0%	6%	5%	6%	7%	7%	3%
Reduction in monthly average EC at CCWD Old Riv.		0%	-1%	18%	20%	20%	18%	15%	10%
Reduction in monthly average EC at CCWD Rock S.		0%	0%	23%	25%	25%	25%	21%	14%
Fatal Flaws		**Notes**							
Material availablity	yes	Gate option requires little fill material							
Residence time in Franks Tract		Peak modeled residence time = 8 days							
Recreational impacts		Blocks boat passage from southern Old River							

Legend

Fatal flaw

Beneficial change

Neutral change

Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

Cox Alternative – Fatal Flaw Matrix

EXHIBIT 3.3-18

Class	Isolation	West Gates		North Levees				East Levees	East Gates
Alternative	No Franks Tract	West False River Gate	False River and Piper Gates	East Side Open	N. Levee and Nozzle Gate	Nozzle Gate and Piper Gate	N. Levee and Close Little Franks Tract	East Levee and Gates	Cox Alternative
Impact on Salinity									
Reduction in monthly average EC at SWP pumps	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩
Reduction in monthly average EC at CVP pumps	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩
Reduction in monthly average EC at CCWD Old Riv.	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩
Reduction in monthly average EC at CCWD Rock S.	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩
Fatal Flaws									
Material availablity	no	yes	yes	yes	yes	yes	yes	yes	yes
Residence time in Franks Tract	n/a	⇩	⇩	⇧	⇧	⇩	⇧	⇧	⇧
Recreational impacts	⇩	⇩	⇩	⇩	⇧	⇧	⇧	⇩	⇩

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

Source: NHI 2005

Preliminary Alternatives
Summary Comparison Fatal Flaw Screening Matrix

EXHIBIT 3.3-19

4 FINAL PREFERRED ALTERNATIVES DESCRIPTION AND ANALYSIS

The final preferred alternatives description and analysis follows several important steps that build on previous evaluations, including the opportunities and constraints analysis and preliminary alternatives development and analysis. This chapter develops, describes, and analyzes a set of preferred alternatives, using a final preferred alternatives formulation process, evaluation criteria, summary comparison, and benefit–cost analysis.

4.1 FINAL PREFERRED ALTERNATIVES FORMULATION PROCESS

The most promising locations and configurations for application of water quality, ecosystem restoration, and recreation tools were grouped into four comprehensive alternatives for achieving the full suite of study objectives.

Of the nine preliminary water quality alternatives described in Chapter 3, two possessed fatal flaws (No Franks Tract and East Side Open). The remaining seven were reduced to the final four alternatives by grouping similar alternatives and selecting a single final alternative for each group. For example, the most promising of the three north levee water quality alternatives was selected for detailed analysis in this chapter. The water quality alternatives not selected should not be eliminated from potential further consideration because it is possible that further modeling analyses of gate operation optimization may significantly improve water quality benefits. Because the alternatives not selected for detailed analysis are relatively similar to at least one of the final alternatives, the final four described below serve as a proxy for the entire group in this analysis.

The four most promising water quality alternatives selected for further analysis and formulation of preferred alternatives are:

< West False River Gate
< North Levee and Two Gates[1]
< East Levee and Two Gates[2]
< Cox Alternative

The final four water quality alternatives were combined with geographically compatible ecosystem and recreational elements from the following list to create the final alternatives described in detail below. Not all ecosystem and recreation elements listed below are included in each alternative, because some of them are not consistent with some of the final four water quality alternatives.

POCKET MARSHES

< West pocket marsh

---

[1] Previously referred to as North Levee, Nozzle Gate, and Piper Slough Gate alternative.
[2] Previously referred to as East Levee and Gates alternative.

< Northwest pocket marsh
< Northeast pocket marsh

LITTLE FRANKS TRACT MARSH RESTORATION

HABITAT LEVEES

< North habitat levee
< East habitat levee
< North Little Franks Tract habitat levee
< South Little Franks Tract habitat levee

POCKET BEACHES

< West pocket beach
< Northwest pocket beach
< Northeast pocket beach
< South pocket beach
< East pocket beach

OTHER RECREATION ELEMENTS

< Boat locks
< Mooring areas
< Floating campgrounds

4.2 EVALUATION CRITERIA

The final alternatives were evaluated in greater detail than the preliminary alternatives comparison. The final alternatives were evaluated for:

< Water Quality

- Salinity at the export/diversion facilities
- Salinity at Jersey Point
- Salinity in Middle River and Victoria Canal
- Residence time in Franks Tract
- Potential for transport of DOC from Franks Tract to the export / diversion facilities

< Ecosystem

- Acres of tidal marsh created
- Connectivity of created tidal marsh with existing habitat
- Likely impact on Egeria in Franks Tract

< Recreation

- Impact on existing boating access
- Acres of constructed beaches in Franks Tract
- Number and location of mooring areas constructed in Franks Tract

< Island Stability

- Impact on stability of adjacent islands and levees
- Change in maximum stage
- Change in water velocities

< Implementation

- Cost (capital)
- Engineering feasibility
- Sustainability
- Ability to implement in an incremental manner

4.3 PREFERRED ALTERNATIVES

4.3.1 WEST FALSE RIVER GATE ALTERNATIVE

The West False River Gate alternative improvement elements are depicted in Exhibit 4.3-1 and screening criteria matrix is detailed in Exhibit 4.3-2.

WATER QUALITY ELEMENTS

The West False River Gate alternative proposes to place an operable gate across West False River, near the confluence with the San Joaquin River. The gate, as modeled, is closed on flood tide and partially (1/3 or 20,000 cubic feet per second [cfs]) open on ebb tide. The improvement over a simple closed flood–open ebb operation suggests that the performance of this alternative as well as all other alternatives could be greatly improved by optimizing gate operation. This alternative serves as a proxy for the False River and Piper Slough gate preliminary alternative that also used gates to prevent salt water from entering Franks Tract via False River. It is likely that the False River and Piper Slough alternative would perform much better if the gate operation were optimized.

For the purpose of preliminary modeling runs, the gates would be closed on flood tide and open 1/3 on ebb tide. In actuality, control of the gates could operate on local or regional salinity triggers to minimize salinity at the export facilities. Gates would likely remain open from January to summer and would begin operating when salinity levels in the Delta achieve a predetermined threshold. The details of daily or tidal operation require additional modeling.

The West False River Gate, as modeled, greatly reduces salinity concentrations at all the export/diversion facilities and at Jersey Point in the western Delta. The improvement at the export/diversion facilities is accomplished by preventing salt water from entering Franks Tract on flood tides. Franks Tract would remain fresher and would not mix salt water as it does under current conditions. This alternative appears to reduce salinity at Jersey Point because fresh water leaves Franks Tract on ebb tide and is transported seaward to Jersey Point. Under the modeled operations, salinity in Middle River and Victoria Canal would increase in late fall. The gate operation increases salinity intrusion through the San Joaquin River around Webb Tract increasing the transport of salt into Middle River and Victoria Canal. The ebb flow from False River into the San Joaquin River is fresher than under the North Levee and Two Gates alternative (described below). The fresh water that leaves Franks Tract in the West False River Gate option may increase salinity in Middle River and Victoria Canal by mixing fresh water into the San Joaquin River. Potential effects associated with the modeled increases at these two locations are unclear; however, the modeled increases in salinity are well below south Delta agriculture station standards (see Exhibits 2.2-1 and 4.3-2). Optimized operations of the gate may reduce the salinity increase in Middle River and Victoria Canal in the late fall.

Peak modeled residence time in Franks Tract would reduce from 4 days to 3 days under the West False River Gate alternative. The operation of the gates would prevent a significant increase in residence time. The increase in tidal marsh habitat (see text below) may produce slightly more DOC in Franks Tract than in the base condition. However, any increase could be offset by a reduction in residence time and changes in hydrodynamics that would direct more of the water from Franks Tract into False and San Joaquin Rivers and less southward toward the export/diversion facilities.

ECOSYSTEM ELEMENTS

The primary ecosystem elements integrated into the West False River Gate alternative are the restoration of Little Franks Tract and pocket marshes in the south, northwest, northeast, and east portions of Franks Tract. Ecosystem benefits associated with a habitat levee along the northern perimeter of Franks Tract and Little Franks Tract are not included in this alternative.

Depending on how and when the gate would be closed, this alternative could increase Egeria infestation in Franks Tract. Assuming that Egeria establishment is largely controlled by peak velocities, as opposed to total volumes, it may be possible to limit additional Egeria establishment in high-velocity areas by intermittently keeping the gates open on ebb tide to maintain a sufficient frequency of high-velocity scour events through Franks Tract. Additionally, this alternative could block in rafts of hyacinth that wouldn't be flushed away and therefore stimulate more growth.

This alternative would not significantly disrupt movement of native migratory fish because it would operate primarily in summer and early fall, when vulnerable, young fish would not be present. San Joaquin River fall-run chinook salmon migrate through the Delta in the fall months, but operation of the barrier would not impede their migration because the barrier would be open at least half the time. It is possible that operation of the barrier could have the positive effect of directing more adult fish away from Old River and into the Middle and San Joaquin Rivers, where their prospects of successful migration would be greater. Sacramento River salmon migration routes would be largely unaffected by this alternative. The individual fish from those runs that did pass by the proposed gate structure would be less likely to stray into Franks Tract and Old River under this alternative. Delta smelt still present in the central Delta during June, when gate operations commence, would presumably benefit from the increased net westward flow induced by this alternative. This alternative could disrupt the distribution of early juvenile striped bass during June, but it is unclear how this would affect overall population levels.

RECREATIONAL ELEMENTS

Among the four final alternatives, this alternative would create the least disruption to boating. As in all the final alternatives, boat navigation locks are to be placed in tandem with gate structures to allow boat passage when the gates are closed; however, the location of this gate would be less disruptive to navigation. Because of the location of the gate, boaters who elected not to use the navigation lock could avoid the closed gate by using Fisherman's Cut and the San Joaquin River. For boaters en route to Brannon Island or the Sacramento River, which represents a large fraction of boats traveling through False River, this is already the most direct and preferred route. Thus, this gate would not disrupt navigation from Brannon Island to Franks Tract or from any other points in the central or southern Delta to Franks Tract. Optimization of gate operation would probably result in closing the gates less often than assumed in the model run, thereby reducing any navigation delays when the gate is closed.

The creation of four pocket beaches (associated with pocket marshes) is also included in this alternative. The beaches would be located in areas with natural shelter from prevailing strong winds and wind-wave fetch forces for sustainability and recreational enjoyment purposes. Other recreational improvement elements, such as mooring areas and floating campgrounds, could be added at varying locations in association with the tidal gate and pocket beach locations.

ISLAND STABILITY

As with other alternatives, the east extension of Little Franks Tract Marsh would appear to reduce wind-wave erosion on Bethel Island between Willow Road and the end of Piper Road. This alternative would provide no wind-wave attenuation for the remnant levees or the Webb Tract levees on the north side of Franks Tract, because it does not include the north habitat levee.

The West False River Gate alternative may result in velocity increases in Fisherman's Cut and Old River. Velocity decreases of up to 2.6 feet per second (ft/s) are expected in False River because of the reduced flow during the ebb tide. Peak velocities are also decreased by about 1.3 ft/s through the main nozzle. Overall peak velocities in Franks Tract are also reduced. Potential effects resulting from changes in velocities are unclear due to the complex nature of geomorphic processes (e.g., scour, erosion, sediment transport and deposition) and the unknown state of levee conditions at these locations.

No changes in maximum flood stage were observed during modeling runs for this alternative. It is not anticipated that the gate would be operated from January to June when velocities and flood stages are highest.

COST

The planning, design, and construction cost of West False River Gate alternative is estimated to be approximately $309,940,000. This is the second least expensive of the alternatives that were considered. The large operable gate on west False River comprises over 60% of the cost. The remainder of the cost is for the creation of tidal marsh on Little Franks Tract and the construction of pocket beaches and habitat on the interior of Franks Tract. All four alternatives include these features. This cost estimate is conservatively high, as it includes a 30% contingency and an additional 25% for associated engineering, legal, and administrative services. Operational and adaptive management/monitoring costs are not included in this analysis. Costs are discussed in greater detail in the cost-benefit section below.

DISCUSSION OF BENEFITS AND IMPACTS

This is one of the least expensive alternatives and would offer slightly greater water quality benefits than the other alternatives. The primary disadvantage of this alternative is that it would require an extremely large and expensive water quality control gate on False River. The superior water quality benefits may result from the fact that this was the only water quality alternative with partial gate optimization in the initial model runs. It is likely that similar gate optimization for the other alternatives would yield significant increases in water quality as well.

The West False River Gate alternative would be the least disruptive to navigation because the gate would not be on a major boat traffic artery and could be easily circumnavigated. The ecological benefits of the West False River Gate alternative are similar to other alternatives, except that it does not include a habitat levee on the north or east side of Franks Tract. As a result there are no wind-wave attenuation benefits associated with the habitat levees, but the west pocket marsh included in this and other alternatives would attenuate wind-wave action on the northeast shore of Bethel Island.

Identification and evaluation of potential impacts associated with changes in salinity concentrations, water velocities, and maximum and minimum stage are discussed in detail in Chapter 5 and would be further analyzed during the environmental review process.

RELATIONSHIP TO OBJECTIVES

A summary of the West False River Gate alternative relationship to study objectives is provided in Table 4.3-1 below.

Table 4.3-1 West False River Gate Alternative Relationship to Objectives		
Objective	Alternative Element(s)	Relationship
Objective 1: Habitat Diversification Approaches to Achieve Ecosystem, Water Quality, and Recreation (and other social) Benefits	Pocket Beach/Marsh Little Franks Tract Marsh	Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem) Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem); and wind-wave fetch reduction (social - flood control)
Objective 2: Ecosystem Restoration	Pocket Beach/Marsh Little Franks Tract Marsh	Tidal marsh and riparian scrub habitat creation Tidal marsh and riparian scrub habitat creation
Objective 3: Water Quality Improvement	False River Gate	Salinity reductions in south Delta
Objective 4: Recreation and Other Social Benefits	Pocket Beach/Marsh Little Franks Tract Marsh	Beach creation Wind-wave fetch and levee erosion reduction

4.3.2 NORTH LEVEE AND TWO GATES ALTERNATIVE

The North Levee and Two Gates alternative improvement elements are depicted in Exhibit 4.3-3 and screening criteria matrix is detailed in Exhibit 4.3-4.

WATER QUALITY ELEMENTS

The North Levee and Two Gates alternative proposes to reconstruct the north levee to Old River. The alternative includes a gate in the main nozzle between False River and Franks Tract to control extremely long residence time in Franks Tract and allow for adaptive management and the possibility of growing carbon. This alternative also includes a gate on Piper Slough to prevent salt water from entering Franks Tract via Piper Slough, yet maintain boat passage between Piper Slough and Franks Tract.

This alternative serves as a proxy for the two similar preliminary alternatives that also included a setback levee along the north levee and gates in the nozzle to reduce mixing in Franks Tract and salinity at the export/diversion facilities.

For the purpose of preliminary modeling runs, the gates were closed on flood tide and open on ebb tide. In actuality, the gates would likely be operated using a combination of flow and salinity triggers to minimize salt concentrations at the pumps. The gates would likely be open from January to summer and would begin operating when salinity levels in the Delta achieve a predetermined threshold. The water quality performance of this alternative and the two similar alternatives in this category may increase substantially with such gate optimization. Optimal gate operations require additional modeling.

The North Levee and Two Gates alternative (as modeled) would effectively reduce salinity at the pumps and at Jersey Point. The gate on Piper Slough, the gate on the nozzle, and the reconstructed north levee would reduce the amount of salt water entering Franks Tract from False River. The alternative may reduce salinity at Jersey Point because fresh water leaving Franks Tract on ebb tide would be transported seaward to Jersey Point. Under the modeled operations, salinity in Middle River and Victoria Canal and at selected export/diversion facilities would increase in late fall. The gates and levees increase salinity intrusion through the San Joaquin River around Webb Tract increasing the transport of salt into Middle River and Victoria Canal. The ebb flow from False River into the San Joaquin River is not as fresh as under the West False River Gate alternative. The fresh water that appears to flush from Franks Tract in the West False River Gate alternative may serve to diminish some of the increase in Middle River and Victoria Canal by mixing some fresh water into the San Joaquin River. Potential effects associated with the modeled increases are unclear at this time; however, the modeled increases in salinity at these two locations are well below south Delta agriculture station standards (see Exhibits 2.2-1 and 4.3-4). Optimized operations of the gate may reduce this salinity increase in Middle River and Victoria Canal and at the export/diversion facilities in the late fall.

Peak modeled residence time in Franks Tract would be reduced from 4 days to 3 days under the North Levee and Two Gates alternative. The increase in tidal marsh habitat (see text below) might produce slightly more DOC in Franks Tract than under the base condition. However, this slight increase might be offset by a reduction in residence time and changes in hydrodynamics that would direct more of the water from Franks Tract out into False River and the San Joaquin River and less southward toward the pumps.

ECOSYSTEM ELEMENTS

The primary ecosystem elements integrated into this alternative are the restoration of Little Franks Tract and pocket marshes in the west, northwest, northeast, and east portions of Franks Tract, as well as a north habitat setback levee along Franks Tract and Little Franks Tract. The north habitat levee could protect habitat on remnant levees and mid-channel islands from further erosion.

Depending on how and when the water quality gate is closed, this alternative could increase Egeria infestation in Franks Tract. Assuming that Egeria establishment is largely controlled by peak velocities, as opposed to total volumes, it may be possible to limit additional Egeria establishment in high-velocity areas by intermittently opening the gates on ebb tide to maintain a sufficient frequency of high-velocity scour events through Franks Tract. Closing the levee breaches on the north side of Franks Tract might increase Egeria locally. This effect, however, might be offset by excavation of sand mounds on the interior of Franks Tract to build the north habitat setback levee. Additionally, restored tidal marsh associated with the north levee would replace current Egeria beds in those locations. This alternative, like West False Gate alternative, could block in rafts of Hyacinth and therefore stimulate more growth.

This alternative would not negatively disrupt movement of native migratory fish because it would be operated primarily in the summer and early fall, when vulnerable, young fish are not present. The north habitat levee feature could benefit juvenile salmon by reducing connectivity to the interior of Franks Tract where they are prone to predation. San Joaquin fall-run chinook salmon migrate through the Delta in the fall months. The nozzle gate would not significantly impede their migration because the barrier would be open at least half the time. It is possible that operation of the gate may have the beneficial effect of directing more adult fish away from Franks Tract and Old River and into Middle and San Joaquin Rivers, where their prospects of successful migration would be greater. Sacramento River salmon migration routes would be largely unaffected by this alternative. The individual fish from those runs that did pass by the proposed gate structure would be less likely to stray into Franks Tract and Old River under this alternative. Delta smelt still present in the central Delta during June, when gate operations commence would presumably benefit from the increased net westward flow induced by this alternative. This alternative could disrupt the distribution of early juvenile striped bass during June, but it is unclear how this would affect overall population levels.

RECREATIONAL ELEMENTS

Like all the preferred alternatives, navigation locks would be placed in tandem with gate structures to allow boat passage when the gates are closed; however, the location of these gates may be less disruptive to navigation than the East Levee and Two Gates and Cox alternatives. Unlike the East Levee and Two Gates and Cox alternatives, this alternative would not disrupt navigation from any points in the central or south Delta to Franks Tract. Because of the location of the gates, boat traffic moving westward from Franks Tract that elected not to use the navigation locks could circumnavigate the closed gates by entering False River via the northeast corner of Franks Tract. Optimization of the gate operation would probably result in closing the gates less often than assumed in the model run, thereby reducing any navigation delays when the gate is closed.

The creation of four pocket beaches (associated with pocket marshes) is included in this alternative. The beaches would be located in areas with natural shelter from prevailing strong winds and wind-wave fetch forces, for sustainability and recreational enjoyment purposes. Other recreational improvement elements, such as mooring areas and floating campgrounds, could be added at varying locations in association with the tide gate and pocket beach locations.

ISLAND STABILITY

Like all other alternatives, the east extension of Little Franks Tract marsh would appear to reduce wind-wave erosion on Bethel Island between Willow Road and the end of Piper Road. This alternative would also provide wind-wave attenuation for the remnant levees and the

Webb Tract levees on the north side of Franks Tract, because it includes the north habitat levee. The north habitat setback levee along Little Franks Tract would reduce erosion of Little Franks remnant levee system, thereby reducing future wind-wave erosion problems on the north shore of Bethel Island that will most likely occur, assuming the Little Franks Tract levee system will eventually erode.

The North Levee and Two Gates alternative results in peak velocity increases in Fisherman's Cut (1.6 ft/s) and in Old River near False River (1.9 ft/s). Peak velocities near the nozzle are increased by as much as 3.6 ft/s. There is little or no increase in Piper Slough. Peak velocities increase by approximately 0.3 ft/s through out most of Taylor Slough. Near its junction with Dutch slough, peak velocities are increased by 1.3 ft/s. Potential effects resulting from changes in velocities are unclear due to the complex nature of geomorphic processes (e.g., scour, erosion, sediment transport and deposition) and the unknown state of levee conditions at these locations.

No changes in maximum flood stage were observed during modeling runs for this alternative. It is not anticipated that the gates would be operated from January to June when velocities and flood stages are highest.

COST

The planning, design, and construction cost of North Levee and Two Gates alternative is estimated to be approximately $324,238,000. This is the second most expensive of the alternatives considered. The two operable gates, the construction of a setback levee along the existing remnant north levee, and a constriction on False River comprise over 60% of the cost. The remainder of the cost is for the creation of tidal marsh on Little Franks Tract and the construction of pocket beaches and habitat on the interior of Franks Tract. All four alternatives include these features. This cost estimate is conservatively high, because it includes a 30% contingency and an additional 25% for associated engineering, legal, and administrative services. Operational and adaptive management/monitoring costs are not included in this analysis. Costs are discussed in greater detail in the cost benefit section below.

DISCUSSION OF BENEFITS AND IMPACTS

This alternative is about 10% more expensive than the lowest cost alternative, but the water quality benefits are significantly less than the three other alternatives. Lower water quality benefits may result from the fact that gate operations were not optimized for this alternative. The modeled operation assumes gates fully closed on flood tide and fully open on ebb tide; this enhances salt transport eastward along the San Joaquin River north of Webb Tract and into Old River. Gate operation optimization could mitigate for intrusion of salinity into Old River from the San Joaquin River, and potentially increase the water quality benefits associated with this alternative.

As with the West False River Gate alternative, the north levee alternative is also one of the least disruptive to navigation because the gates are located on a less traveled route and could be easily circumnavigated. The north habitat setback levee would provide the primary ecological island/stability advantage of this alternative. The north levee will protect habitat, provide a migratory fish corridor, and reduce the potential for native fish to stray into Franks Tract. This alternative also shows the most promise for operating the gates to enhance primary productivity in Little Franks Tract or Franks Tract. This alternative may locally increase Egeria in the areas adjacent to existing levee breaches in the north levee that would be eliminated when the north habitat levee is constructed; however, restored tidal marsh associated with the north levee would replace existing Egeria beds in these locations.

Identification and evaluation of potential impacts associated with changes in salinity concentrations, water velocities, and maximum and minimum stage is discussed in additional detail in Chapter 5 and would be further analyzed during the environmental review process.

RELATIONSHIP TO OBJECTIVES

A summary of the North Levee and Two Gate alternative relationship to study objectives is provided in Table 4.3-2 below.

4.3.3 EAST LEVEE AND TWO GATES ALTERNATIVE

The East Levee and Two Gates alternative improvement elements are depicted in Exhibit 4.3-5 and screening criteria matrix is detailed in Exhibit 4.3-6.

WATER QUALITY ELEMENTS

The East Levee and Two Gates alternative would reconstruct the east levee along Old River and construct gates between Old River and False River, and Old River and Sand Mound Slough. An option for a third gate option across Old River between the reconstructed levee and Mandeville Island was also identified, however, operation of the third gate was not included in the modeling. For the purpose of preliminary modeling runs, the two gates were assumed to be inoperable barriers. In actuality, the gates would be operated to optimize water quality benefits while minimizing any potential adverse impacts associated with increased residence times in Franks Tract. Additional modeling and analysis is necessary to better assess how the two gates would be operated to optimize water quality and environmental conditions.

The East Levee and Two Gates alternative would reduce salinity at the pumps significantly. The reconstructed east levee and gates along Old River would prevent salinity from reaching the pumps by isolating Franks Tract from Old River, allowing fresh water to pass from the Mokelumne River southward toward the pumps. Salinity in Middle River and Victoria Canal would increase slightly, but the least of all the final alternatives. Like the West False River Gate alternative, potential effects associated with the modeled increases are unclear at this time; however, the modeled increases in salinity at these two locations are well below south Delta agriculture station standards (see Exhibits 2.2-1 and 4.3-6).

Table 4.3-2
North Levee and Two Gate Alternative Relationship to Objectives

Objective	Alternative Element(s)	Relationship
Objective 1: Habitat Diversification Approaches to Achieve Ecosystem, Water Quality, and Recreation (and other social) Benefits	False River Setback/Habitat Levee	Integrated levee (water quality), beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem)
	Pocket Beach/Marsh	Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem)
	Little Franks Tract Marsh	Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem); and wind-wave fetch reduction (social - flood control)
	Piper Slough and Horseshoe Bend	Integrated velocity/erosion reduction (flood control), riparian scrub and tidal marsh habitat creation (ecosystem)
Objective 2: Ecosystem Restoration	False River Setback/Habitat Levee	Tidal marsh and riparian scrub habitat creation
	Pocket Beach/Marsh	Tidal marsh and riparian scrub habitat creation
	Little Franks Tract Marsh	Tidal marsh and riparian scrub habitat creation
Objective 3: Water Quality Improvement	False River Setback Levee	Incremental approach to achieve salinity reductions in south Delta (additional phases would be required to fully achieve water quality improvement)
Objective 4: Recreation and Other Social Benefits	Pocket Beach/Marsh	Beach creation
	Little Franks Tract Marsh	Wind-wave fetch and levee erosion reduction
	Piper Slough and Horseshoe Bend	Velocity/erosion reduction

Peak modeled residence time in Franks Tract would increase dramatically from 4 to 12 days in the East Levee and Two Gates alternative. This is likely due to the gates being modeled as inoperable barriers in the preliminary model runs. Operating the gates on a tidal cycle would likely reduce the residence time in Franks Tract to less than 12 days. The increase in tidal marsh habitat (see text below) and increased residence time may produce more DOC in Franks Tract than in the base condition. However, the levee and gates would prevent the Franks Tract DOC from traveling to the pumps.

ECOSYSTEM ELEMENTS

The primary ecosystem elements integrated into the East Levee and Two Gates alternative are the restoration of Little Franks Tract and pocket marshes in portions of Franks Tract, as well as ecosystem benefits associated with an east habitat setback levee. Ecosystem benefits associated with a habitat levee along the northern perimeter of Franks Tract and Little Franks Tract are not included in this alternative. The east habitat levee would protect tidal wetlands along the margin of Quimby Island from wind-wave erosion and create approximately 35 acres of habitat along the eastern edge of Franks Tract and along the margins of Old River. This habitat is not particularly valuable to native fish because it would either be on the interior of Franks Tract, where Egeria is abundant, or along the Old River corridor, where fish are vulnerable to entrainment in the drinking water diversions.

Depending on how and when the water quality gates are closed, this alternative could increase Egeria infestation in Franks Tract. Assuming that Egeria establishment is largely controlled by peak velocities, as opposed to total volumes, it may be possible to limit additional Egeria establishment in high-velocity areas by intermittently opening one or two of the east levee gates on ebb tide to maintain a sufficient frequency of high velocity scour events through Franks Tract. This alternative, like West False Gate alternative, could block in rafts of Hyacinth and therefore stimulate additional growth.

Although residence time would increase under this alternative, it does not appear to be at a level to cause noxious algal blooms in Frank's Tract. High wind-wave action and related mixing within Franks Tract would reduce the likelihood of noxious algal blooms and/or reduced dissolved oxygen, regardless of residence time. Increased DOC production in Franks Tract resulting from increased residence times should not result in increased DOC levels at the export / diversion facilities because Franks Tract is hydrologically disconnected from the southern Delta under this alternative. The gate operation could be optimized to potentially enhance production and transport of phytoplankton to the western Delta, resulting in an increase of overall food web productivity for native fish in the western Delta.

This alternative has the greatest potential to disrupt migratory native fish, particularly Delta smelt and winter run chinook salmon during December in years with low fall stream flows. Because this alternative would increase salinity concentrations in Franks Tract, opening gates on flood tide before the first freshets of the rainy season could greatly increase salinity in the south Delta. Maintaining a closed gate on flood tide across eastern False River could trap Delta smelt in the entrainment zone of Old River and Holland Cut. Similarly, this alternative could induce San Joaquin River chinook salmon moving into a migratory dead end in Old River during September and October when the Old River barrier is in place.

For the most part, however, this alternative would not negatively disrupt movement of native migratory fish because it would be operated primarily in summer and fall, when more vulnerable, young fish are not present. If operated during June, this alternative may disrupt the distribution of early juvenile striped bass during this time. However, it is likely that the gates in this alternative would not need to be operated until after June when most striped bass have grown to a less vulnerable size. Increased residence time in Franks Tract under this alternative may increase food supply for juvenile striped bass. Sacramento River salmon migration routes would be largely unaffected by this alternative unless they stray into Franks Tract; at which point, they could become trapped depending on gate operation.

RECREATIONAL ELEMENTS

As with all the final alternatives, navigation locks would be placed in tandem with gate structures to allow boat passage when the gates are closed. The East Levee and Two Gates alternative would have the greatest impact on navigation due to their locations. All boat traffic traveling from Bethel Island to Old River would have to use navigation locks when the gates are closed. Because a large fraction of boat traffic to and from Franks Tract travels via Old River, this alternative would disrupt boat traffic the most. Optimization of the operation of the gates would reduce the amount of time the gates are closed, thereby reducing conflicts.

The creation of four pocket beaches (associated with pocket marshes) is included in this alternative. The beaches are located in areas with natural shelter from prevailing strong winds and wind-wave fetch forces thus providing maximum sustainability and recreational enjoyment. Additional beach areas would be created associated with the east levee along Old River. Other recreational improvement elements, such as mooring areas and floating campgrounds, may be added at varying locations in association with the tidal gate and pocket beach locations.

ISLAND STABILITY

Like all the other alternatives, the east extension of Little Franks Tract marsh would greatly reduce wind-wave erosion on Bethel Island between Willow Road and the end of Piper Road. This alternative would also provide wind-wave attenuation for the levees along Mandeville Island and would protect the tidal marsh along the perimeter of Quimby Island from further erosion.

The East Levee and Two Gates alternative results in peak velocity increases in Fisherman's Cut and in Old River east of Franks Tract of 1.6 ft/s. Near the Sand Mound Slough gate, peak velocities decrease by as much as 2.3 ft/s to near zero. Velocities on the eastern side of Franks Tract are greatly diminished. Potential effects resulting from changes in velocities are unclear due to the complex nature of geomorphic processes (e.g., scour, erosion, sediment transport and deposition) and the unknown state of levee conditions at these locations.

Because the east levee element might constrain the flow of water from east to west, it may increase flood stage levels in the south Delta. Modeling analysis under January 1997 flood conditions indicated that peak stages in the south Delta would increase by approximately 1.4 inch. Modeling analysis of the 1998 January spring tide indicated no changes in peak stage. It is not anticipated that the gates would be operated from January to June when velocities and flood stages are highest.

COST

The planning, design, and construction cost of East Levee and Two Gates alternative is estimated to be approximately $324,238,000. This is the most expensive of the alternatives considered. The two operable gates and the construction of a setback levee along the existing remnant east levee comprised over 50% of the cost. The remainder of the cost is for the creation of tidal marsh on Little Franks Tract and the construction of pocket beaches and habitat on the interior of Franks Tract. All four alternatives include these features. This cost estimate is conservatively high, because it includes a 30% contingency and an additional 25% for associated engineering, legal, and administrative services. Operational and adaptive management/monitoring costs are not included in this analysis. Costs are discussed in greater detail in the cost benefit section below.

DISCUSSION OF BENEFITS AND IMPACTS

The East Levee and Two Gate alternative is more than 25% more expensive than the least costly alternative, but it yields the highest salinity reduction benefits even without gate optimization. Decreased circulation and associated rises in residence time and potential Egeria establishment are the primary drawbacks of this alternative. It is likely that optimization of gate operation could substantially increase salinity reduction benefits and reduce residence time and potential negative Egeria effects associated with this alternative. It is also possible that the gates could also be operated to grow and transport phytoplankton to increase food web productivity in the western Delta for native fish. Depending on gate operation, this alternative has the greatest potential for adversely effecting chinook salmon, Delta smelt, and native fish species in the central Delta during late fall and early winter.

This alternative would have the greatest negative effects on navigation because boating traffic along Old River or from Franks Tract to Old River would have to pass through navigation locks when the gates are closed. The east habitat levee feature would provide marginal habitat benefits and would substantially reduce wind-wave erosion on Mandeville Island.

Identification and evaluation of potential impacts associated with changes in salinity concentrations, water velocities, and maximum and minimum stage is discussed in additional detail in Chapter 5 and would be further analyzed during the environmental review process.

RELATIONSHIP TO OBJECTIVES

A summary of the East Levee and Two Gate alternative relationship to study objectives is provided in Table 4.3-3 below.

Table 4.3-3
East Levee and Two Gate Alternative Relationship to Objectives

Objective	Alternative Element(s)	Relationship
Objective 1: Habitat Diversification Approaches to Achieve Ecosystem, Water Quality, and Recreation (and other social) Benefits	Old River Setback/Habitat Levee	Integrated levee (water quality), beach (recreation), riparian scrub and tidal marsh habitat creation (ecosystem), and erosion reduction (social – flood control)
	Pocket Beach/Marsh	Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem)
	Little Franks Tract Marsh	Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem); and wind-wave fetch reduction (social - flood control)
	Piper Slough and Horseshoe Bend	Integrated velocity/erosion reduction (flood control), riparian scrub and tidal marsh habitat creation (ecosystem)
Objective 2: Ecosystem Restoration	Old River Setback/Habitat Levee	Tidal marsh and riparian scrub habitat creation
	Pocket Beach/Marsh	Tidal marsh and riparian scrub habitat creation
	Little Franks Tract Marsh	Tidal marsh and riparian scrub habitat creation
Objective 3: Water Quality Improvement	Old River Setback Levee	Incremental approach to achieve salinity reductions in south Delta (additional phases would be required to fully achieve water quality improvement)
Objective 4: Recreation and Other Social Benefits	Pocket Beach/Marsh	Beach creation
	Little Franks Tract Marsh	Wind-wave fetch and levee erosion reduction
	Piper Slough and Horseshoe Bend	Velocity/erosion reduction

4.3.4 COX ALTERNATIVE

The Cox alternative improvement elements are depicted in Exhibit 4.3-7 and screening criteria matrix is detailed in Exhibit 4.3-8.

WATER QUALITY ELEMENTS

The Cox alternative places permanent non-operable flashboard barriers on either side of Quimby Island in Old River and Holland Cut. For the purpose of preliminary modeling runs, the flashboard barriers were installed on June 1 and removed after water quality conditions in the Delta improved in mid-winter. Installation of the flashboard barriers would most likely be based on water quality conditions in a given year.

The Cox alternative would reduce salinity at the export/diversion facilities by isolating Franks Tract from the southern reach of Old River. Salinity in Franks Tract would increase; however, the salinity is prevented from reaching the pumps by the barriers in Holland Cut and Old River along Quimby Island. The model predicts an increase in salinity at Jersey Point, Middle River, and Victoria Canal in late fall. The small increase at Jersey Point is likely due to increased salinity levels in Franks Tract in late fall. The increase in Middle River and Victoria Canal may be due to increased salinity entering from Middle River. Potential effects associated with the modeled increases are unclear at this time; however, the modeled increases in salinity at these three locations are well below south Delta agriculture station standards (see Exhibits 2.2-1 and 4.3-8).

Peak modeled residence time in Franks Tract would increases from 4 to 8 days. The increase in tidal marsh habitat (see below) and increased residence time may increase DOC production in Franks Tract compared to the base condition. However, the gates would direct more of the water from Franks Tract out into the San Joaquin River and Old River and less southward toward the export/diversion facilities.

ECOSYSTEM ELEMENTS

The primary ecosystem elements integrated into this alternative are the restoration of Little Franks Tract and pocket marshes in portions of Franks Tract. Ecosystem benefits associated with a habitat levee along the northern or eastern perimeter of Franks Tract and Little Franks tract are not included in this alternative.

This alternative should not disrupt movement of migratory fish because it is outside of the major migration corridor for all fish of concern. During barrier closure, vulnerable fish would be prevented from entering the Old River which is a migratory dead end. It is possible; however, the fish entrainment reduction benefits associated with this barrier operation could be offset by increased fish entrainment from Middle River.

RECREATIONAL ELEMENTS

Like all the final alternatives, navigation locks would be placed in tandem with the seasonal barrier structures to allow boat passage when the barriers are in, However, the location of the two barriers across the Old River and Holland Cut corridors would cause adverse effects on navigation. Although the navigation effects would not be as great as those under the East Levee and Two Gates alternative, they would still disrupt a large amount of boating traffic that currently travels along this corridor. This alternative, however, would not disrupt boating traffic to and from the northern and central Delta from Franks Tract or Bethel Island.

The creation of four pocket beaches (associated with pocket marshes) is included in this alternative. The beaches are located in areas with natural shelter from prevailing strong winds and wind-wave fetch forces thus providing maximum sustainability and recreational enjoyment. Other recreational improvement elements, such as mooring areas and floating campgrounds, may be added at varying locations in association with the tidal gate and pocket beach locations.

ISLAND STABILITY

Like all the other alternatives, the east extension of Little Franks Tract marsh would greatly reduce wind-wave erosion on Bethel Island between Willow Road and the end of Piper Road. This alternative would not reduce wind-wave fetch in any other location because it does not involve the construction of a habitat levee. This alternative would not increase winter flood stage in the southern Delta because the barriers would be removed during the winter and spring months.

The Cox alternative results in peak velocity increases of 1.9 ft/s in Middle River between San Joaquin River and Mildred Island, and in Connection Slough adjacent to the south end of Mandeville Island. Peak velocities are near zero in Old River and Holland Cut north of the barriers and for much of the southeast corner of Franks Tract. Potential effects resulting from changes in velocities are unclear due to the complex nature of geomorphic processes (e.g., scour, erosion, sediment transport and deposition) and the unknown state of levee conditions at these locations.

No changes in maximum flood stage were observed during modeling runs for this alternative. It is not anticipated that the barriers would be in place from January to June when velocities and flood stages are highest.

COST

The planning, design, and construction cost of Cox Alternative is estimated to be approximately $294,239,000. This is the least expensive of the alternatives considered. The two permanent barriers comprised over 60% of the cost. The remainder is for the creation of tidal marsh on Little Franks Tract and the construction of pocket beaches and habitat on the interior of Franks Tract. All four alternatives include these features. This cost estimate is conservatively high, because it includes a 30% contingency and an additional 25% for associated engineering, legal, and administrative services. Operational and adaptive management/monitoring costs are not included in this analysis. Costs are discussed in greater detail in the cost benefit section below.

DISCUSSION OF BENEFITS AND IMPACTS

This alternative is the least expensive option and provides substantial water quality benefits, even without barrier operation optimization. Disruption of boating traffic along the heavily traveled Old River and Holland Cut channels is the primary drawback of this alternative. This alternative does not include any habitat setback levees, and thus would not provide any of the associated habitat and/or island stability benefits associated with the habitat levees.

Identification and evaluation of potential impacts associated with changes in salinity concentrations, water velocities, and maximum and minimum stage is discussed in additional detail in Chapter 5 and would be further analyzed during the environmental review process.

RELATIONSHIP TO OBJECTIVES

A summary of the Cox alternative relationship to study objectives is provided in Table 4.3-4 below.

Table 4.3-4
Cox Alternative Relationship to Objectives

Objective	Alternative Element(s)	Relationship
Objective 1: Habitat Diversification Approaches to Achieve Ecosystem, Water Quality, and Recreation (and other social) Benefits	Pocket Beach/Marsh	Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem)
	Little Franks Tract Marsh	Integrated beach (recreation), riparian scrub, and tidal marsh habitat creation (ecosystem); and wind-wave fetch reduction (social - flood control)
Objective 2: Ecosystem Restoration	Pocket Beach/Marsh	Tidal marsh and riparian scrub habitat creation
	Little Franks Tract Marsh	Tidal marsh and riparian scrub habitat creation
Objective 3: Water Quality Improvement	Old River and Holland Cut Barriers	Salinity reductions in south Delta
Objective 4: Recreation and Other Social Benefits	Pocket Beach/Marsh	Beach creation
	Little Franks Tract Marsh	Wind-wave fetch and levee erosion reduction

4.4 SUMMARY ALTERNATIVES COMPARISON

A summary comparison of all of the preferred alternatives is presented in Exhibit 4.3-9.

4.5 BENEFIT-COST ANALYSIS

To properly evaluate the comparative effectiveness of each project alternative considered in this study, it was necessary to not focus solely on each alternative's estimate of probable construction cost (cost) or quantification of estimated benefits (benefits), but rather to integrate both factors into a benefit-cost analysis. The intent of such an analysis is to allow project team members, decision makers, and project stakeholders to more effectively understand the comparative effectiveness of each alternative, based on the parameters of benefit and cost.

The benefit-cost analysis performed for the Flooded Islands Pre-Feasibility Study consisted of five stages of analysis:

1. Development of a "Toolkit Matrix" (toolkit)
2. Estimation of Probable Construction Costs
3. Quantification of Estimated Benefits
4. Determination of a Benefit-Cost Index
5. Summarization of Analysis Results

4.5.1 TOOLKIT MATRIX

The toolkit provided below shows the construction elements and potential recreational boat-in beaches and habitat acreages developed for each alternative. At the bottom of the toolkit, a summary of the beach and habitat acreage developed within each project alternative is provided. The following construction elements are included in the toolkit:

< Flow control structures

< Pocket beaches and habitat

< Levee restoration

< Marsh creation on Little Franks Tract

FLOW CONTROL STRUCTURES

Three different flow control structures were included in the toolkit:

< Permanent non-operable gates

< Operable gates

< Flow constrictions within existing channels

Each facility has been described elsewhere in this report. For further discussion, please reference Section 3.1, "Toolkit." The toolkit below identifies the flow control structures included in each project alternative (Exhibit 4.5-1).

POCKET BEACHES AND HABITAT

Analysis of coastal engineering processes within Franks Tract identified five locations (pockets) for placement of beaches or habitat. These pocket locations are identified for each alternative in Section 4.3, "Preferred Project Alternatives." Each location has been anchored by a setback levee (see Section 3.1) with habitat on the external/slough side of the setback levee core and can be configured with either beach or additional habitat on the interior Franks Tract side of the setback levee. The toolkit identifies the utilization of each pocket location in each project alternative, as well as their respective beach and habitat areas (in acres).

LEVEE RESTORATION

Two preliminary alternatives and one preferred project alternative, "North Levee," incorporate levee restoration ("Habitat Levees," as described in Section 3.1) as part of the proposed improvements. The proposed levee designs incorporate habitat, and in the case of the East Levee and Two Gates alternative, provisions for beach construction as a part of the levee restoration concept. The toolkit above (Exhibit 4.5-1) identifies the restoration of the levees in each project alternative, as well as the respective beach and habitat areas (in acres) associated with the levee restoration.

MARSH CREATION ON LITTLE FRANKS TRACT

All project alternatives consider the creation of 420 acres of tidal marsh within Little Franks Tract. Marsh would be created by placing fill materials within Little Franks Tract to raise grades to an elevation of approximately –0.5 NGVD.

4.5.2 COST CALCULATION

For each project alternative, a construction cost estimate was developed for each construction element. Table 4.5-1 and Exhibit 4.5-2 summarize the estimated cost of each construction element, as well as the total cost for each project alternative. In addition, the following allowances were added for each alternative construction cost estimate:

< Contingency: 30%

< Engineering, legal, and administration: 25%

Key estimating assumptions follow:

< The costs for all flow control structures were derived from an analysis of the bid results for the Montezuma Slough Salinity Control Structure, constructed in 1985. The costs were apportioned to four project items:

Table 4.5-1
Flooded Islands Pre-Feasibility Study Preferred Alternatives Summarized Cost Estimates

Description	Quantity	Unit	Unit Price	Sub-Total	Contingency @ 30%	Engineering / Legal / Administration @ 25%	Total Cost
West False River Gate Alternative							
Operable Gate	1	ls	$118,469,000	$118,469,000	$35,541,000	$38,503,000	$192,513,000
Pocket Beaches/Habitat	62	acres	$261,830	$16,312,000	$4,894,000	$5,302,000	$26,508,000
Little Franks Tract Marsh Creation	420	acres	$133,214	$55,950,000	$16,785,000	$18,184,000	$90,919,000
TOTAL COST				$190,731,000	$57,220,000	$61,989,000	$309,940,000
North Levee and Two Gates Alternative							
Nozzle Gate	1	ls	$67,226,000	$67,226,000	$20,168,000	$21,849,000	$109,243,000
Close North Levee On Franks Tract	12,374	lf	$1,236	$15,292,000	$4,588,000	$4,970,000	$24,850,000
Piper Slough Gate	1	ls	$40,852,000	$40,852,000	$12,256,000	$13,277,000	$66,385,000
Constriction On False River	1	ls	$214,000	$214,000	$64,000	$70,000	$348,000
Pocket Beaches/Habitat	62	acres	$261,830	$16,312,000	$4,894,000	$5,302,000	$26,508,000
Little Franks Tract Marsh Creation	420	acres	$141,983	$59,633,000	$17,890,000	$19,381,000	$96,904,000
TOTAL COST				$199,529,000	$59,860,000	$64,849,000	$324,238,000
East Levee and Two Gates Alternative							
False River Gate	1	ls	$55,343,000	$55,343,000	$16,603,000	$17,987,000	$89,933,000
Close East Levee On Franks Tract	8,682	lf	$1,248	$10,839,000	$3,252,000	$3,523,000	$17,614,000
Sand Mound Slough Gate	1	ls	$40,557,000	$40,557,000	$12,167,000	$13,181,000	$65,905,000
Pocket Beaches/Habitat	62	acres	$261,830	$16,312,000	$4,894,000	$5,302,000	$26,508,000
Little Franks Tract Marsh Creation	420	acres	$141,857	$59,580,000	$17,874,000	$19,364,000	$96,818,000
TOTAL COST				$182,631,000	$54,790,000	$59,357,000	$296,778,000
Cox Alternative							
Seasonal Barrier In Old River	1	ls	$60,647,000	$60,647,000	$18,194,000	$19,710,000	$98,551,000
Seasonal Barrier In Holland Cut	1	ls	$48,161,000	$48,161,000	$14,448,000	$15,652,000	$78,261,000
Pocket Beaches/Habitat	62	acres	$261,830	$16,312,000	$4,894,000	$5,302,000	$26,508,000
Little Franks Tract Marsh Creation	420	acres	$133,214	$55,950,000	$16,785,000	$18,184,000	$90,919,000
TOTAL COST				$181,070,000	$54,321,000	$58,848,000	$294,239,000

- Access roads/embankments
- Boat lock structure
- Flashboard structure
- Salinity control structures

All costs were then escalated from 1985 values by a factor of 1.74 to 2005 values, based on the Engineering News Record's Construction Cost Index.

< For non-operable gates, the first two items were assumed to be "lump sum" features that would be the same cost regardless of location in the Delta because their overall function and resulting design would not change from location to location. The cost for the flashboard structure was related to channel width and calculated on this basis. The fourth item was excluded from this calculation because this item represents the "operable" portion of the flow control structures.

For the operable gates, the first three items were assumed to be "lump sum" features that would be the same cost regardless of location in the Delta since their overall function and resulting design would not change from location to location. The Salinity Control Structure cost was related to the hydraulic design capacity of 6,000 cubic feet per second (peak tidal flow), as stated in the Basic Design Criteria and Constraints (DWR 1985), to arrive at a unit cost per cubic feet per second (cfs) of capacity. Thus, the cost of each Salinity Control Structure was determined by multiplying the unit cost ($/cfs) by the estimated peak daily tidal flow estimated at each structure location.

All setback levees and pocket beaches and habitats were based on the rock dike setback levee concept described in Section 3.1.

< For all project elements requiring fill material, the following assumptions were made:

- Analysis of exposed remnant sand mounds within Franks Tract indicated approximately 2,500,000 cubic yards (cy) of sand could be obtained by dredging these features in Franks Tract. The cost of this activity was estimated to be $4/cy.

- For project elements requiring greater than 2,500,000 cy of fill material, but requiring placement of the material within Franks Tract at individual estimated quantities of less than 1,000,000 cy, it was assumed that material would be obtained from Decker Island at an estimated cost of $15/cy.

- For the marsh creation project element on Little Franks Tract, requiring approximately 4,800,000-cy of fill material, it was assumed that material would be obtained from Decker Island at an estimated cost of $10/cy because of the economy of scale offered by such a large quantity.

For all project elements requiring rock material, the rock was estimated to cost $50/cy ($30/ton).

4.5.3 BENEFIT CALCULATION

Based on the results of hydrodynamic modeling, a table of salinity reduction benefits (benefits), expressed as percent change relative to baseline conditions, was prepared for each month of the modeling period (June 2002 through December 2002). These benefits were determined for each primary water export/diversion point within the south Delta, namely:

- State Water Project (SWP)
- Central Valley Project (CVP)
- Contra Costa Water District at Old River (CCWD Old River)
- Contra Costa Water District at Rock Slough (CCWD Rock Slough)

For each diversion point, the seven monthly benefits were then summarized to give a numerically averaged benefit value for each project alternative. Because significant differences exist in the volume of water diverted at each diversion point, it was necessary to adjust the benefits calculation by applying a weighting factor based on the relative difference between diversion volumes at the four diversion points. Tables 4.5-2 and 4.5-3 and Exhibits 4.5-3 through 4.5-5 present the results of this calculation process.

Table 4.5-2
Flooded Islands Pre-Feasibility Study Diversion Point Volumes

Month	SWP	CVP	CCWD - Old River	CCWD – Rock Slough
	% of total	% of total	% of total	% of total
June	42.2	49.6	4.8	3.3
July	56.8	40.2	1.7	1.4
August	60.4	38.8	0.7	0.2
September	49.1	50.0	0.7	0.2
October	29.2	69.6	1.0	0.2
November	46.1	52.9	0.9	0.2
December	54.8	44.5	0.5	0.2
AVERAGE	50.5	47.5	1.3	0.7

Source: Moffat & Nichol 2005

BENEFIT-COST ANALYSIS

With the cost and benefit calculations completed, the next step in the analysis is to determine the Benefit-Cost Index (BCI). The BCI is a unit-less value for each project alternative that provides a means of allowing comparative analysis of each alternative, based on the evaluation parameters of benefit and cost.

Table 4.5-3 Flooded Island Pre-Feasibility Study Weighted Benefits Calculation Table— Individual Diversion Points						
Alternative	Average Weighted %	% Reduction in Average EC (umhos/com) June 2002–December 2002				
		SWP	CVP	CCWD Old River	CCWD Rock Slough	SUMMARY
		% reduc. 50.5%	% reduc. 47.5%	% reduc. 1.3%	% reduc. 0.7%	(Average %) (Summed %)
West False River Gate	Average %	10.3	6.9	15.6	18.1	12.7
	Weighted %	5.2	3.3	0.2	0.1	8.8
North Levee and Two Gates	Average %	2.0	0	7.1	11.5	5.2
	Weighted %	1.0	0.0	0.1	0.1	1.2
East Levee and Two Gates	Average %	13.3	9.1	19.5	23.0	16.2
	Weighted %	6.7	4.3	0.3	0.2	11.4
Cox Alternative	Average %	8.4	4.6	14.4	19.1	11.6
	Weighted %	4.2	2.2	0.2	0.1	6.7

Source: Moffat & Nichol 2005

The table and accompanying figures below present the results of the Benefit-Cost Analysis by project alternative for each diversion point, as well as a summary average. To determine the BCI, the scale of each data set had to be brought into line to result in a BCI value that is near 1. To accomplish this, the benefits percentage value was multiplied by 100. Next, the cost values were divided by 1,000,000 to get each data set on a 100 scale. The BCI is then calculated by dividing the benefits value (in 100 scale) by the cost value (in 100 scale). The resulting values provide a relative measure of each project alternative's cost-effectiveness in achieving salinity reduction benefits. For example, the higher the BCI, the more effective the alternative is. Table 4.5-4 and Exhibits 4.5-6 and 4.5-7 present the results of the BCI calculation process.

RESULTS

Based on the analysis provided herein, several observations can be made:

< East Levee and Two Gates, West False River Gate, and Cox alternatives clearly demonstrate the greatest BCI.

< The West False River Gate, East Levee and Two Gates, and Cox alternatives BCI's are effectively identical. Therefore, it is impossible to select one over the other based on the evaluation parameters of benefit and cost only. Further analysis using other evaluation criteria would be required to select a preferred alternative.

In performing this analysis, additional areas of concern arose; these require further analysis and consideration. The areas of concern include the following:

Table 4.5-4 Flooded Islands Pre-Feasibility Study Weighted Benefit-Cost Index Calculation Table—Individual Diversion Points						
		Benefit-Cost Index Analysis June 2002–December 2002				
		SWP	CVP	CCWD Old River	CCWD Rock Slough	AVERAGE
West False River Gate	Benefit (% * 100)	521.3	327.9	20.2	12.7	2.8
	Cost ($,000,000's)	$309.9	$309.9	$309.9	$309.9	
	Benefit / Cost Index	1.7	1.1	0.1	0.0	
North Levee and Two Gates	Benefit (% * 100)	102.6	0.7	9.2	8.1	0.4
	Cost ($,000,000's)	$324.2	$324.2	$324.2	$324.2	
	Benefit / Cost Index	0.3	0.0	0.0	0.0	
East Levee and Two Gates	Benefit (% * 100)	672.0	430.0	25.4	16.1	3.9
	Cost ($,000,000's)	$296.8	$296.8	$296.8	$296.8	
	Benefit / Cost Index	2.3	1.4	0.1	0.1	
Cox	Benefit (% * 100)	421.9	219.1	18.7	13.4	2.3
	Cost ($,000,000's)	$294.2	$294.2	$294.2	$294.2	
	Benefit / Cost Index	1.4	0.7	0.1	0.0	

Source: Moffat & Nichol 2005

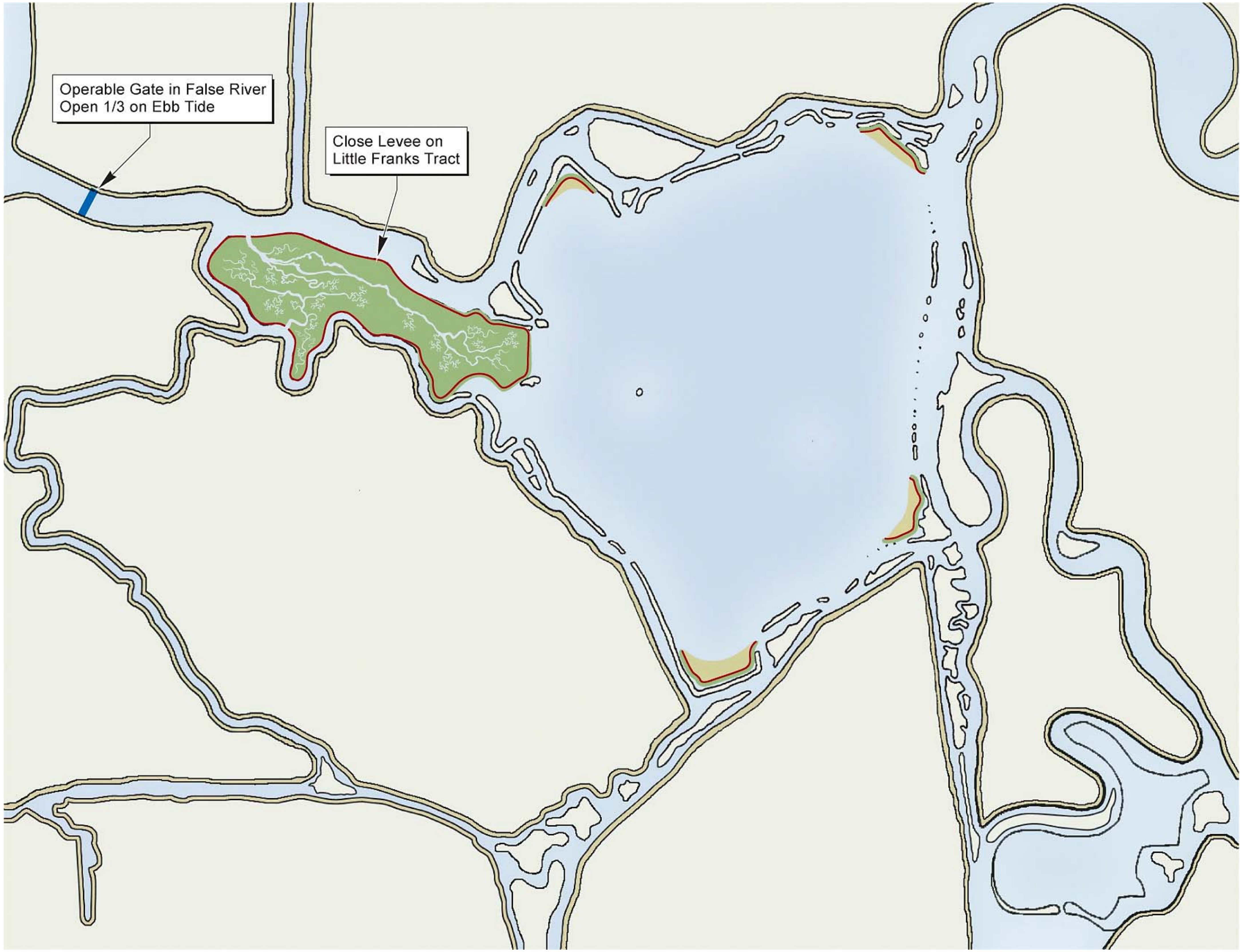
- The present suite of alternatives has been evaluated for the 2002 water year, which represents a "dry year." What would be the effect on these alternatives if modeling was performed using a "drought year" or a "wet year"?

- Because of limited time and budget, only minimal efforts have been made at "optimizing" the development or operation of the alternatives. The little optimization that was done on the West False River Gate alternative, resulted in a greater than 100% improvement in benefit was realized. Such a substantial change points to the need for additional study with regard to optimization of each alternative before elimination of any of the presented project alternatives.

- What would be the effect on the proposed project alternatives from global-warming induced sea level rise?

The evaluation criteria described herein was limited to salinity reduction benefits and cost only. No attempt has been made to refine the benefits analysis based on other evaluation criteria such as habitat or recreation values. However, the effect of these two components has been "neutralized" to some degree by creating approximately the same amount of habitat and recreation benefits within each alternative.

Based on the above comments, clearly additional analyses are necessary before an individual preferred project alternative can be identified.



Alternative Features

1 operable gate

Common Features

Little Franks Tract Marsh Restoration

4 Pocket Beaches

Legend
- Existing Levee
- Rock Dyke
- Gates/Barriers
- Tidal Marsh
- Beaches

Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

West False River Gate Alternative

EXHIBIT 4.3-1

0 1500 3000
FEET
NORTH

EDAW

	Assessment								
Water Quality		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in average monthly EC at SWP pumps	⇩	0%	1%	11%	16%	17%	13%	8%	5%
Reduction in average monthly EC at CVP pumps	⇩	0%	1%	7%	10%	12%	10%	5%	3%
Reduction in average monthly EC at CCWD Old River	⇩	0%	2%	17%	22%	24%	19%	14%	11%
Reduction in average monthly EC at CCWD Rock Slough	⇩	0%	2%	20%	24%	27%	25%	21%	7%
Reduction in average monthly EC at Jersey Point	⇩	0%	14%	29%	30%	29%	28%	25%	23%
Reduction in average monthly EC at Middle River	⇧	0%	-1%	-4%	-3%	-5%	-6%	-7%	-5%
Reduction in average monthly EC at Collinsville	⇧	0%	1%	-1%	-1%	-1%	1%	1%	2%
Reduction in average monthly EC at Emmaton	⇧	0%	-6%	-8%	-9%	-12%	-10%	-9%	-6%
Reduction in average monthly EC at Victoria Canal	⇧	0%	-1%	-4%	-3%	-5%	-6%	-7%	-5%
Change in peak residence time in Franks Tract	■	No change							
DOC (in Franks Tract)	⇧	Slight increase due to increase in tidal marsh							
DOC (at pumps)	■	Change in hydrodynamics sends more Franks Tract water into San Joaquin and north							
Ecosystem		**Notes**							
Acres of tidal marsh habitat created	438								
Protection of existing remnant levee and channel island habitat	Low	No levee repairs in this alternative							
Likely impact on *Egeria* (assumes no effective *Egeria* control)	■	Negligible change to velocities in Franks Tract							
Recreation		**Notes**							
Navigation	⇩	Boat lock on relatively low traffic False River, less access between False River and northern Franks Tract							
Number of beaches	4	4 pocket beaches							
Acres of beaches	44								
Number of mooring areas	5	Assumes a mooring area for every beach and gate/barrier							
Island Stability		**Notes**							
Adjacent island stability	⇧	Reconstructed north levee increases protection of Webb Tract; tidal marsh in west Franks Tract protects Bethel Island							
Stage maximums	■	No change in maximum flood stage							
Implementation		**Notes**							
Cost of water quality features	$192,513,000	Operable gate							
Cost of ecological features*	$90,918,000	Little Franks Tract tidal marsh creation							
Cost of beaches	$26,508,000	Pocket beaches/habitat							
Feasibilty	Yes	Single, very large gate; sufficient material for levee and habitat creation							

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

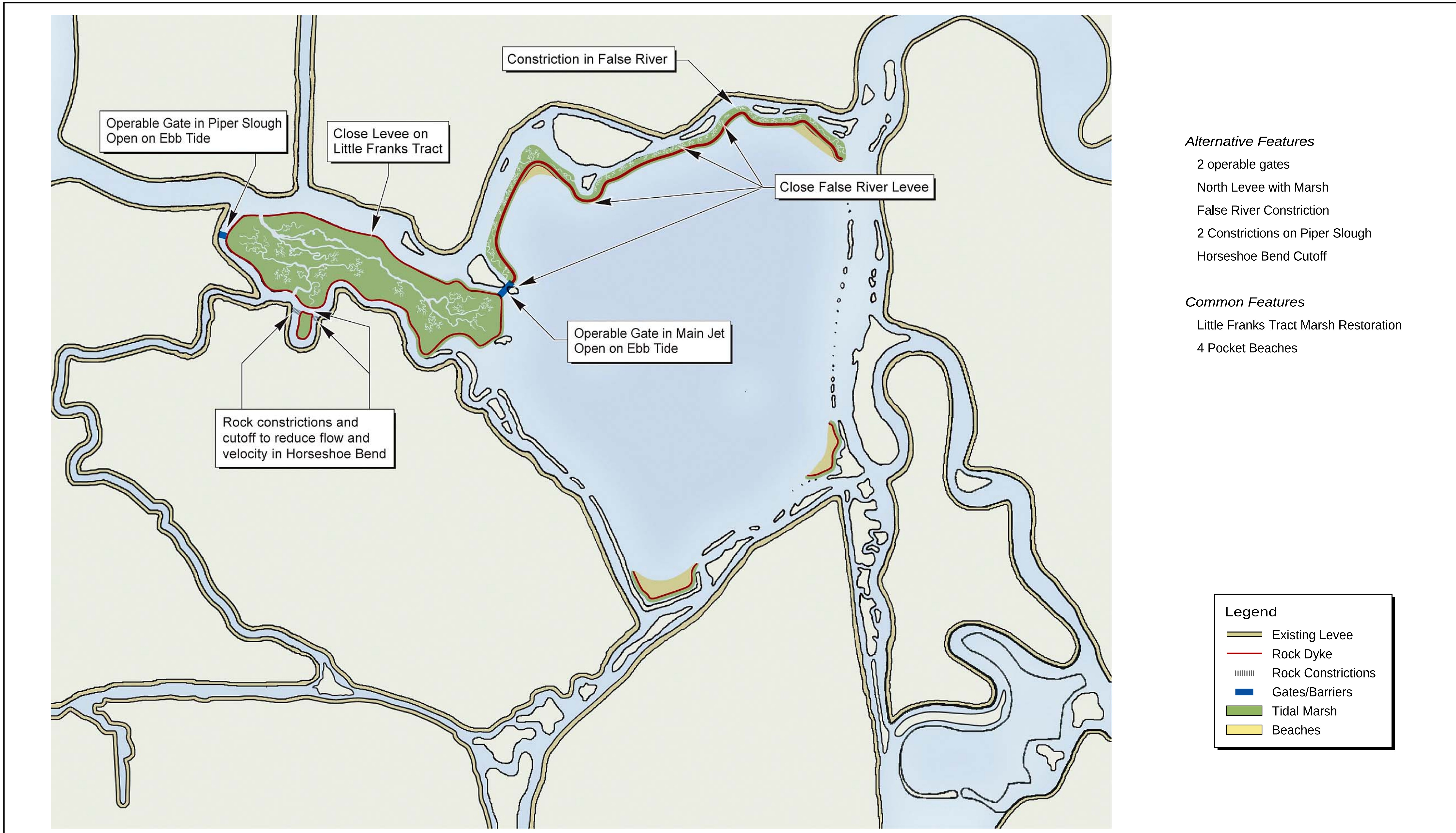
Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

* Incidental habitat benefits are also included in costs of levees and beaches.

Source: NHI 2005

West False River Gate Alternative – Screening Criteria Matrix

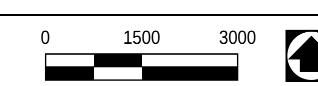
EXHIBIT 4.3-2



Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

North Levee and Two Gates Alternative

EXHIBIT 4.3-3



EDAW

	Assessment								
Water Quality		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in average monthly EC at SWP pumps	↓	0%	0%	4%	10%	8%	2%	-6%	-4%
Reduction in average monthly EC at CVP pumps	↓	0%	0%	1%	5%	4%	0%	-6%	-4%
Reduction in average monthly EC at CCWD Old River	↓	0%	0%	9%	17%	16%	8%	0%	-1%
Reduction in average monthly EC at CCWD Rock Slough	↓	0%	1%	13%	21%	21%	17%	7%	1%
Reduction in average monthly EC at Jersey Point	↓	0%	15%	32%	32%	33%	31%	25%	20%
Reduction in average monthly EC at Middle River	↑	0%	1%	-12%	-15%	-18%	-18%	-21%	-16%
Reduction in average monthly EC at Collinsville	↑	1%	0%	-2%	-2%	-2%	0%	0%	0%
Reduction in average monthly EC at Emmaton	↑	0%	-7%	-8%	-9%	-12%	-11%	-10%	-7%
Reduction in average monthly EC at Victoria Canal	↑	0%	1%	-11%	-15%	-18%	-18%	-21%	-16%
Change in peak residence time in Franks Tract	↓	Very slight decrease in residence time							
DOC (in Franks Tract)	↑	Slight increase due to increase in tidal marsh							
DOC (at pumps)		Change in hydrodynamics sends more Franks Tract water into San Joaquin and north							
Ecosystem		**Notes**							
Acres of tidal marsh habitat created	368								
Protection of existing remnant levee and channel island habitat	High	North levee habitat is adjacent to existing levee habitat and near channel islands							
Likely impact on *Egeria* (assumes no effective Egeria control)	↓	*Egeria* bed in west Franks Tract replaced by tidal marsh							
Recreation		**Notes**							
Navigation	↓	Boat lock on both gates, less access between False River and northern Franks Tract							
Number of beaches	4	4 pocket beaches							
Acres of beaches	44								
Number of mooring areas	6	Assumes a mooring area for every beach and gate/barrier							
Island Stability		**Notes**							
Adjacent island stability	↑	Reconstructed north levee increases protection of Webb Tract; tidal marsh in west Franks Tract protects Bethel Island							
Stage maximums		No change in maximum flood stage							
Implementation		**Notes**							
Cost of water quality features	$200,826,000	Nozzle gate, reconstruct north levee, Piper Slough gate, constriction on False River							
Cost of ecological features*	$96,904,000	Little Franks Tract tidal marsh creation							
Cost of beaches	$26,508,000	Pocket beaches/habitat							
Feasibilty	Yes	Two gates; sufficient material for levee and habitat creation							

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.

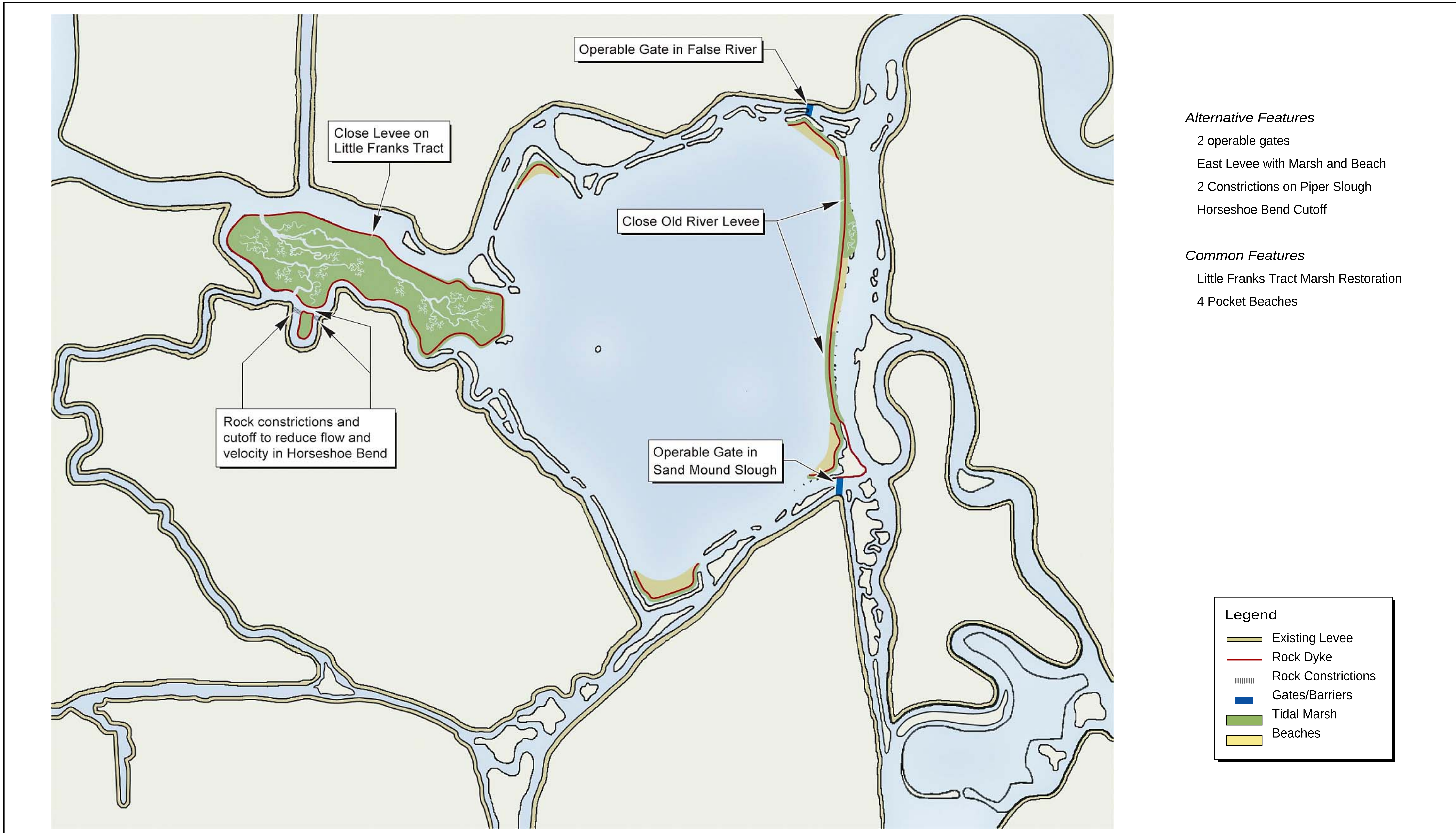
Arrow width indicates magnitude of change.

* Incidental habitat benefits are also included in costs of levees and beaches.

Source: NHI 2005

North Levee and Two Gates Alternative – Screening Criteria Matrix

EXHIBIT 4.3-4



Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

East Levee and Two Gates Alternative

EXHIBIT 4.3-5

0 1500 3000
FEET
NORTH

EDAW

	Assessment								
Water Quality		**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Reduction in average monthly EC at SWP pumps		0%	8%	12%	16%	17%	20%	16%	9%
Reduction in average monthly EC at CVP pumps		0%	7%	7%	10%	12%	15%	11%	6%
Reduction in average monthly EC at CCWD Old River		0%	7%	18%	23%	24%	27%	24%	17%
Reduction in average monthly EC at CCWD Rock Slough		0%	8%	22%	26%	28%	32%	30%	17%
Reduction in average monthly EC at Jersey Point		0%	6%	15%	14%	10%	5%	3%	2%
Reduction in average monthly EC at Middle River		0%	1%	-5%	-7%	-7%	-1%	-1%	-1%
Reduction in average monthly EC at Collinsville		0%	-1%	-1%	-1%	-1%	-1%	-1%	0%
Reduction in average monthly EC at Emmaton		0%	-2%	-3%	-4%	-7%	-6%	-6%	-4%
Reduction in average monthly EC at Victoria Canal		0%	1%	-5%	-7%	-7%	-1%	-1%	-1%
Change in peak residence time in Franks Tract		Significant increase from 4 to 12 days, but gates were modeled as inoperable barriers							
DOC (in Franks Tract)		Increase due to increase in tidal marsh and increased residence time							
DOC (at pumps)		East levee and gates isolate Franks Tract DOC from pumps							
Ecosystem		**Notes**							
Acres of tidal marsh habitat created	370								
Protection of existing remnant levee and channel island habitat	Medium	Very little remaining levee habitat on east levee							
Likely impact on *Egeria* (assumes no effective Egeria control)		Increased residence times and decreased velocities could increase *Egeria*							
Recreation		**Notes**							
Navigation		Boat lock on three gates, significantly less access between Old River and Franks Tract							
Number of beaches	5	4 pocket beaches and beach along east levee							
Acres of beaches	55								
Number of mooring areas	8	Assumes a mooring area for every beach and gate/barrier							
Island Stability		**Notes**							
Adjacent island stability		Reconstructed east levee increases protection of Mandeville Island							
Stage maximums		0.01 m increase in maximum flood stage south of Franks Tract to Victoria Canal							
Implementation		**Notes**							
Cost of water quality features	$173,452,000	False River gate, reconstruct east levee, Old River gate, Sand Mound Slough gate							
Cost of ecological features*	$96,818,000	Little Franks Tract tidal marsh creation							
Cost of beaches	$26,508,000	Pocket beaches/habitat							
Feasibilty	Yes	Three gates; sufficient material for levee and habitat creation							

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.

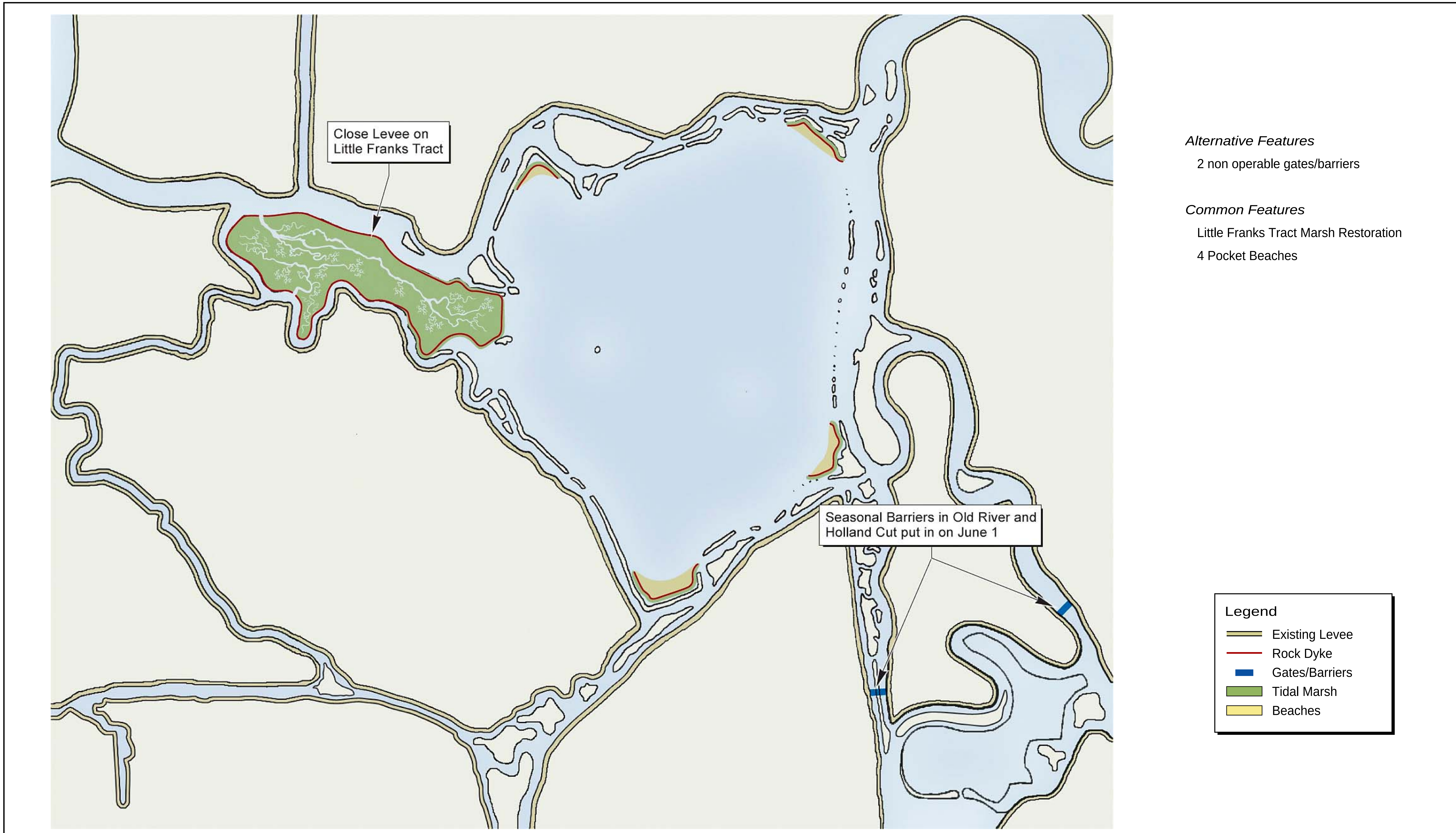
Arrow width indicates magnitude of change.

* Incidental habitat benefits are also included in costs of levees and beaches.

Source: NHI 2005

East Levee and Two Gates Alternative – Screening Criteria Matrix

EXHIBIT 4.3-6



Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

Cox Alternative

EXHIBIT 4.3-7

0 1500 3000
FEET
NORTH
EDAW

Water Quality	Assessment	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Reduction in average monthly EC at SWP pumps		0%	1%	12%	12%	11%	10%	9%	5%
Reduction in average monthly EC at CVP pumps		0%	0%	6%	5%	6%	7%	7%	3%
Reduction in average monthly EC at CCWD Old River		0%	-1%	18%	20%	20%	18%	15%	10%
Reduction in average monthly EC at CCWD Rock Slough		0%	0%	23%	25%	25%	25%	21%	14%
Reduction in average monthly EC at Jersey Point		-1%	4%	6%	4%	1%	-2%	-2%	-2%
Reduction in average monthly EC at Middle River		0%	2%	-8%	-18%	-19%	-11%	-9%	-5%
Reduction in average monthly EC at Collinsville		0%	1%	1%	0%	0%	0%	0%	0%
Reduction in average monthly EC at Emmaton		0%	3%	4%	4%	2%	1%	1%	2%
Reduction in average monthly EC at Victoria Canal		0%	4%	-6%	-18%	-19%	-11%	-9%	-5%
Change in peak residence time in Franks Tract		Increase from 4 to 8 days							
DOC (in Franks Tract)		Increase due to increase in tidal marsh and increased residence time							
DOC (at pumps)		Gates isolate Franks Tract DOC from pumps							

Ecosystem		Notes
Acres of tidal marsh habitat created	355	coming from M&N
Protection of existing remnant levee and channel island habitat	Low	No levee repairs in this alternative
Likely impact on *Egeria* (assumes no effective Egeria control)		Increased residence times could increase *Egeria*

Recreation		Notes
Navigation		Boat lock on three gates, significantly less access between Old River and Franks Tract
Number of beaches	4	4 pocket beaches
Acres of beaches	44	
Number of mooring areas	6	Assumes a mooring area for every beach and gate/barrier

Island Stability		Notes
Adjacent island stability		Reconstructed north levee increases protection of Webb Tract; tidal marsh in west Franks Tract protects Bethel Island
Stage maximums		No change in maximum flood stage

Implementation		Notes
Cost of water quality features	$176,812,000	Seasonal barrier in Old River, seasonal barrier in Holland Cut
Cost of ecological features*	$90,918,000	Little Franks Tract tidal marsh creation
Cost of beaches	$26,508,000	Pocket beaches/habitat
Feasibilty	Yes	Two gates; sufficient material for levee and habitat creation

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.

Arrow width indicates magnitude of change.

* Incidental habitat benefits are also included in costs of levees and beaches.

Source: NHI 2005

Cox Alternative – Screening Criteria Matrix

EXHIBIT 4.3-8

EDAW

	West False River Gate	North Levee, Two Gates	East Levee and Two Gates	Cox
Water Quality				
Reduction in average monthly EC at SWP pumps	↓	↓	↓	↓
Reduction in average monthly EC at CVP pumps	↓	↓	↓	↓
Reduction in average monthly EC at CCWD Old River	↓	↓	↓	↓
Reduction in average monthly EC at CCWD Rock Slough	↓	↓	↓	↓
Reduction in average monthly EC at Jersey Point	↓	↓	↓	↑
Reduction in average monthly EC at Middle River	↑	↑	↑	↑
Reduction in average monthly EC at Collinsville	↑	↑	↑	↑
Reduction in average monthly EC at Emmaton	↑	↑	↑	↑
Reduction in average monthly EC at Victoria Canal	↑	↑	↑	↑
Change in peak residence time in Franks Tract	■	↓	↑	↑
DOC (in Franks Tract)	↑	↑	↑	↑
DOC (at pumps)	■	■	■	■
Ecosystem				
Acres of tidal marsh habitat created	438	481	473	438
Protection of existing remnant levee and channel island habitat	Low	High	Medium	Low
Likely impact on *Egeria* (assumes no effective *Egeria* control)	■	↓	↑	↑
Recreation				
Navigation	↓	↓	↓	↓
Number of beaches	4	4	5	4
Acres of beaches	44	44	55	44
Number of mooring areas	5	6	8	6
Island Stability				
Adjacent island stability (reduction of wind fetch)	↑	↑	↑	↑
Stage maximums	■	■	↑	■
Implementation				
Cost of water quality features	$192,513,000	$200,826,000	$173,452,000	$176,812,000
Cost of ecological features*	$90,919,000	$96,904,000	$96,818,000	$90,918,000
Cost of beaches	$26,508,000	$26,508,000	$26,508,000	$26,508,000
Feasibilty	Yes	Yes	Yes	Yes

Legend

- Fatal flaw
- Beneficial change
- Neutral change
- Detrimental change

Note: Arrows indicate direction of change.
Arrow width indicates magnitude of change.

* Incidental habitat benefits are also included in costs of levees and beaches.

Source: NHI 2005

Summary Alternatives Comparison Matrix

EXHIBIT 4.3-9

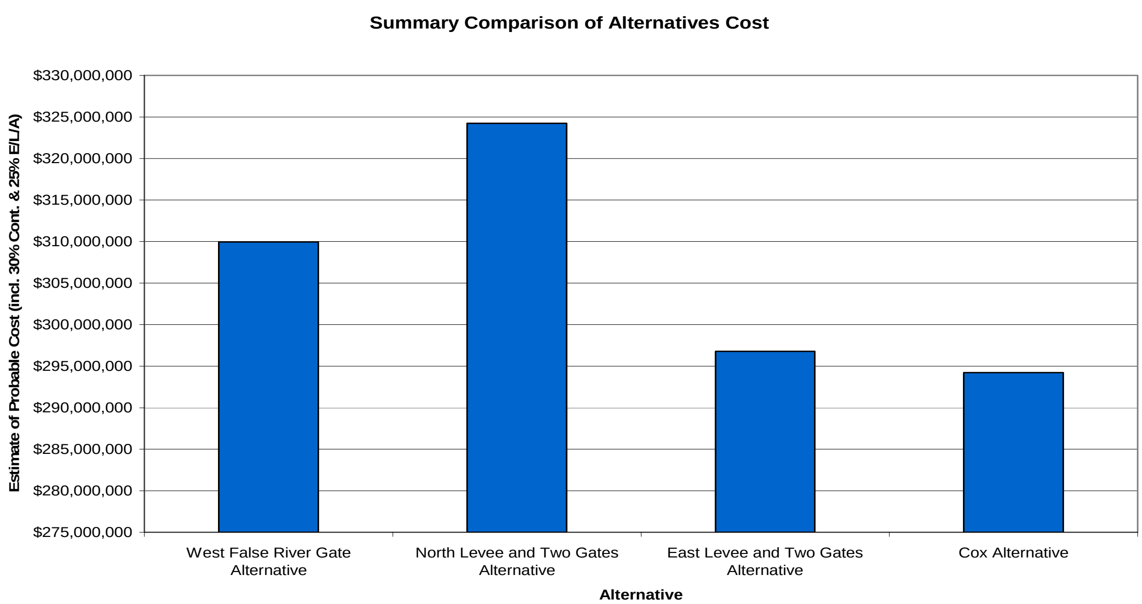
EDAW

			Alternative			
			West False River Gate	North Levee and Two Gates	East Levee and Two Gates	Cox
Non-Operable Gates						2-ea
Operable Gates			1-ea	2-ea	2-ea	
Flow Constrictions				3-ea	2-ea	
Pocket Location	West (60.3-acres)	Habitat	-included within the LFT marsh-			
		Beach				
	Northwest (12.5 - acres)	Habitat	3.9-acres	3.9-acres	3.9-acres	3.9-acres
		Beach	8.6-acres	8.6-acres	8.6-acres	8.6-acres
	Northeast (14.0-acres)	Habitat	4.4-acres	4.4-acres	4.4-acres	4.4-acres
		Beach	9.6-acres	9.6-acres	9.6-acres	9.6-acres
	East (12.9-acres)	Habitat	4.3-acres	4.3-acres	4.3-acres	4.3-acres
		Beach	8.6-acres	8.6-acres	8.6-acres	8.6-acres
	South (22.9-acres)	Habitat	5.5-acres	5.5-acres	5.5-acres	5.5-acres
		Beach	17.4-acres	17.4-acres	17.4-acres	17.4-acres
	Sub-Total (acres)	Habitat	18.1-acres	18.1-acres	18.1-acres	18.1-acres
		Beach	44.2-acres	44.2-acres	44.2-acres	44.2-acres
Levee Restoration	North Levee	Habitat		42.9-acres		
		Beach		0.0-acres		
	East Levee	Habitat			35.3-acres	
		Beach			11.2-acres	
Little Franks Marsh Creation			420-acres	420-acres	420-acres	420-acres
TOTAL HABITAT DEVELOPED			438-acres	481-acres	473-acres	438-acres
TOTAL BEACH DEVELOPED			44-acres	44-acres	55-acres	44-acres

Source: Moffat & Nichol 2005

Exhibit 4.5-1

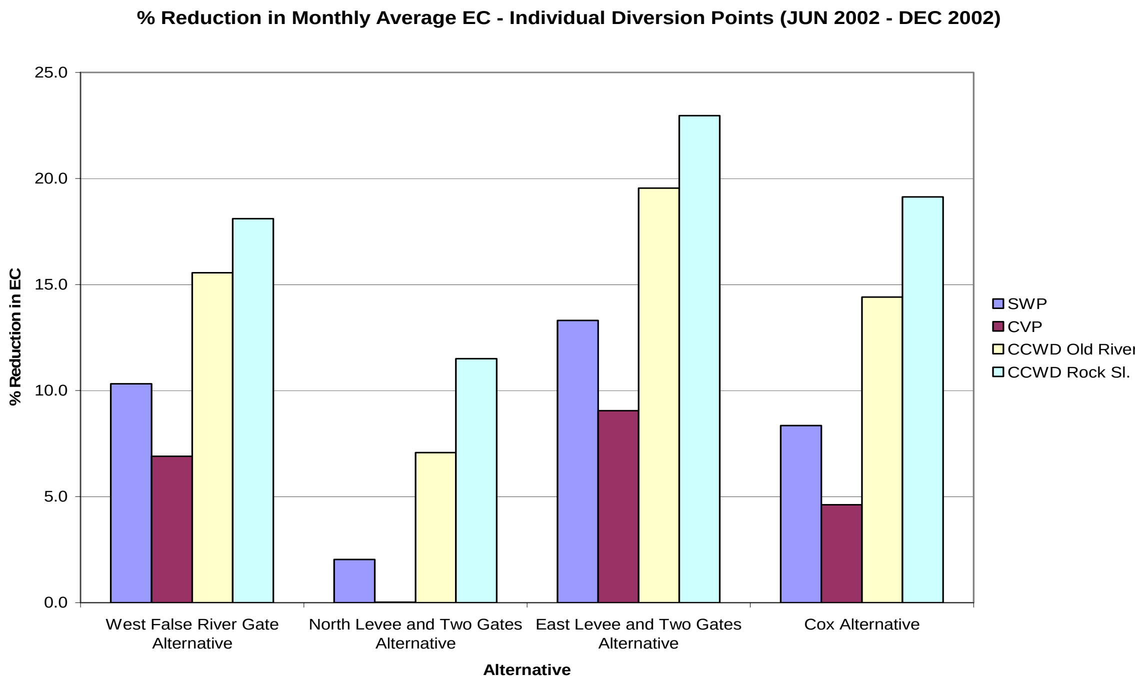
Flooded Islands Pre-Feasibility Study Benefit-Cost Analysis Toolkit Matrix



Source: Moffat & Nichol 2005

Exhibit 4.5-2

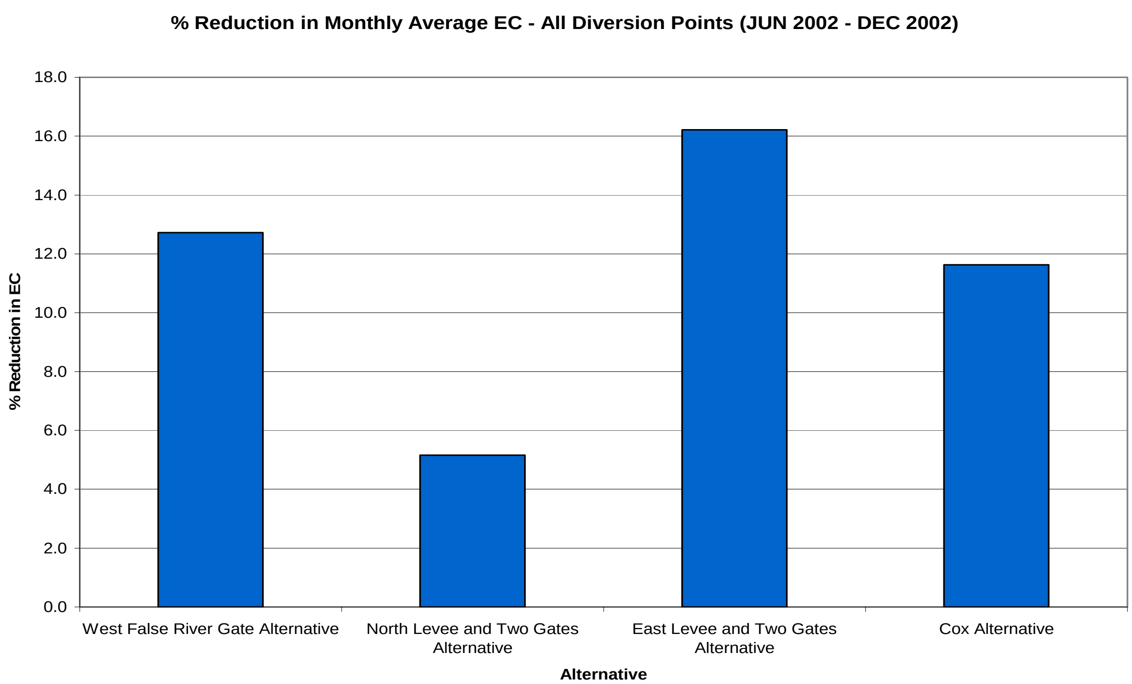
Flooded Islands Pre-Feasibility Study Preferred Alternatives Summarized Cost Estimate



Source: Moffat & Nichol 2005

Exhibit 4.5-3

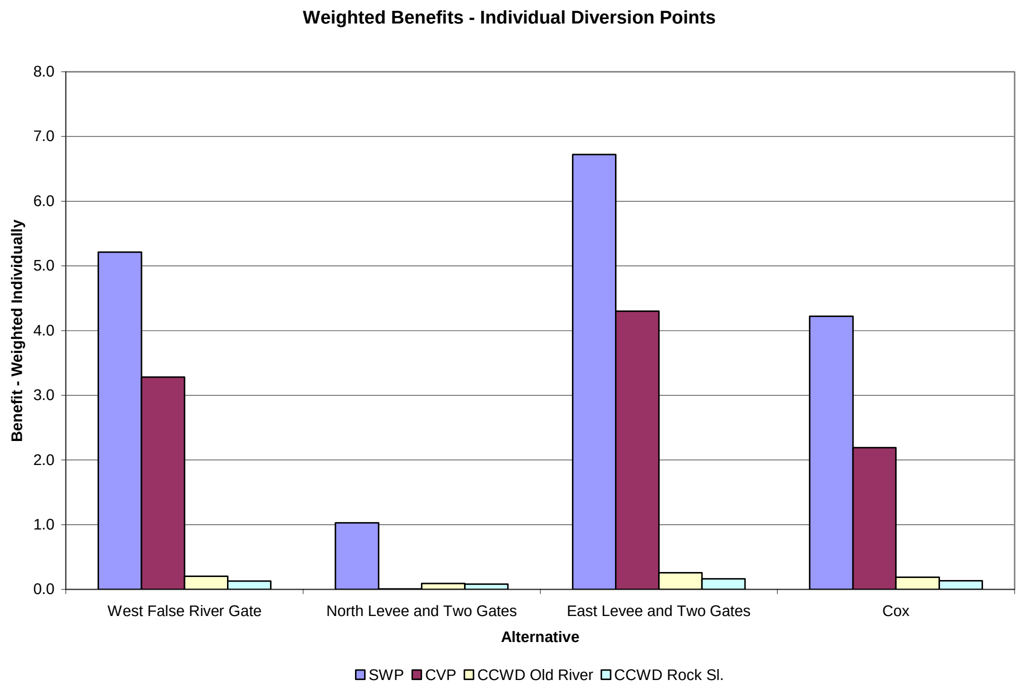
Flooded Island Pre-Feasibility Study Benefits Calculation Figure—Individual Diversion Points



Source: Moffat & Nichol 2005

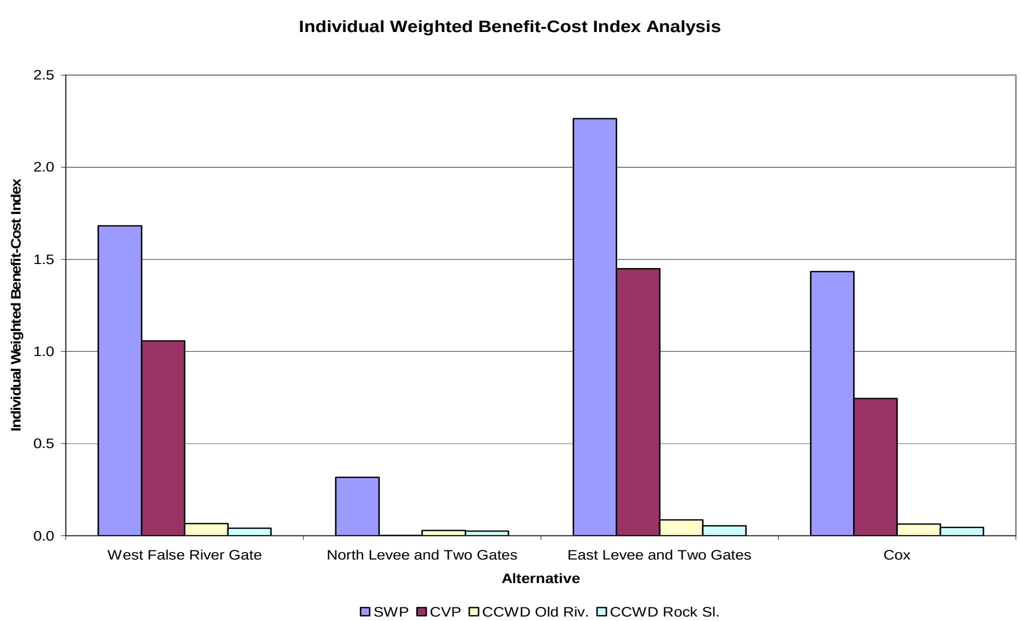
Exhibit 4.5-4

Flooded Island Pre-Feasibility Study Benefits Calculation Figure—All Diversion Points



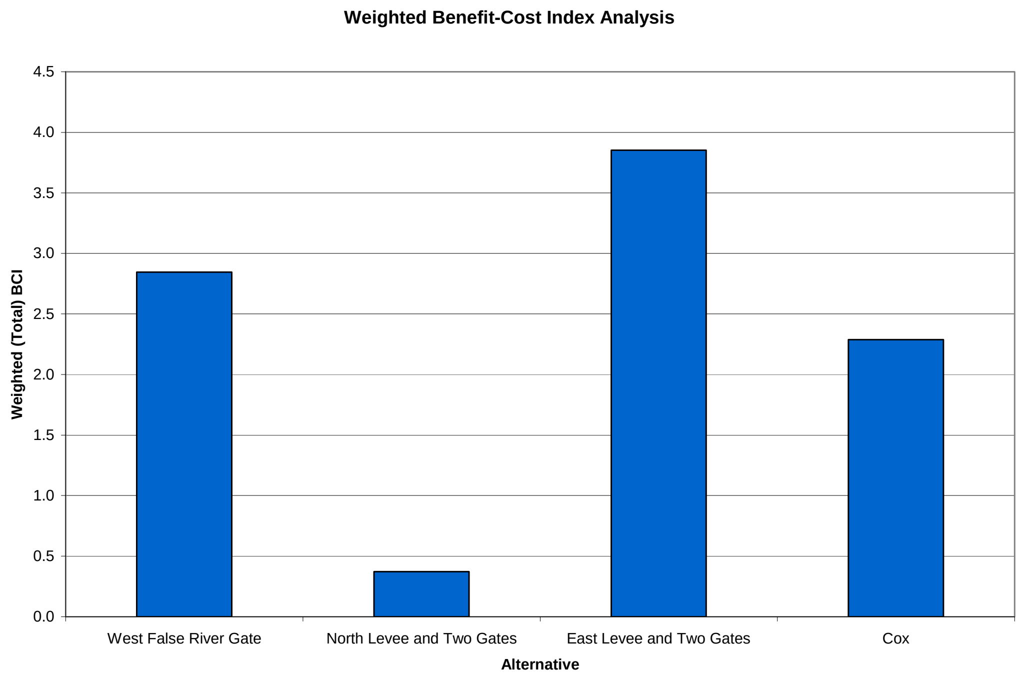
Source: Moffat & Nichol 2005

Exhibit 4.5-5
Flooded Islands Pre-Feasibility Study Weighted Benefits Calculation Figure—Individual Diversion Points



Source: Moffat & Nichol 2005

Exhibit 4.5-6
Flooded Islands Pre-Feasibility Study Weighted Benefit-Cost Index Calculation Figure—Individual Diversion Points



Source: Moffat & Nichol 2005

Exhibit 4.5-7

Flooded Islands Pre-Feasibility Study Weighted Benefit-Cost Index Calculation Figure—All Diversion Points

5 RECOMMENDATIONS

This chapter presents recommendations for alternatives refinement and optimization and includes proposed program development next steps, guidelines for a pilot program, identification of preliminary alternative pilot projects, and environmental compliance and permitting requirements.

5.1 PREFERRED ALTERNATIVES REFINEMENT AND OPTIMIZATION

The four preferred alternatives were developed, described, and analyzed based on modeling, evaluations against objectives, and fatal-flaw analyses. A benefit-cost analysis was also applied for additional evaluation. Although the methodology applied allowed for relatively thorough development, comparison, and contrast; additional refinement and optimization of each alternative is recommended before a single preferred project is identified. The limited refinement of individual alternatives conducted in this study proved that slight adjustments in element configuration and/or operating assumptions (such as gate operations) have potential to result in dramatic water quality improvements. These same adjustments may also have the same effect on achievement of ecosystem restoration and/or recreation improvement objectives. Program development outlined below is designed to facilitate additional refinement, evaluation, and optimization of the alternatives.

5.2 PROGRAM DEVELOPMENT

Proposed next steps for the program development include: alternatives refinement and optimization, final pilot project development and description, pilot project environmental compliance and implementation, and full program environmental compliance and implementation.

5.2.1 ALTERNATIVES REFINEMENT AND OPTIMIZATION

As discussed above, additional refinement and optimization of each of the preferred alternatives is recommended before a single preferred alternative is chosen. The next steps for alternative refinement and optimization should include more precise adjustments in each alternative's configuration and/or operating assumptions. Evaluation of adjustments should include refined hydrodymanic/water quality modeling runs and additional criteria screening. Additional studies, analysis, and/or field data collection should also be conducted, where appropriate, to further evaluate potential project effects on conditions/issues with uncertainties, including many of those identified in the Chapter 2. Next steps and information needs for alternatives refinement and optimization include the following:[1]

[1] A preliminary timeline for general guidance in decisions about future steps is provided. Funding availability, unexpected analysis delays, environmental review process timing, and other circumstances may extend the estimated timeline requirements.

< Additional Studies, Analysis, and Data Collection

- Fisheries field data collection and investigations (with multiyear monitoring)
    - Review and interpretation of current and existing data with specific reference to flooded islands
    - Collect field data and establish focused site-specific baseline conditions (6 to 12 months)
- Egeria response prediction/sensitivity analysis
    - Conduct additional analyses on Egeria colonization condition requirements including substrate, velocity, and water quality
- Long-term issues such as change in morphology due to altered sediment deposition, effect of sea level rise, and levee failure events
- Beach and habitat stability
    - Evaluate techniques and methods for constructing tidal marsh with dendritic channels in flooded island environments
- Additional analysis to better understand study related ecological response issues (e.g., mercury methylation, Egeria and Corbicula response, DOC [ecological and drinking water quality considerations])
    - Development of integrated conceptual models
    - Potential input and review from technical advisory group
- Boating traffic analysis for study area channels and sloughs

< Alternatives Refinement and Optimization (6 months)

- Continued adjustment and refinement of alternatives (project elements and operating assumptions)
- Hydrodynamic and water quality modeling simulation runs of refined alternatives
    - Salinity, velocity, and stage change analysis
- Objectives criteria screening of refined alternatives
- Weighted benefit-cost analysis (including operational)
- Identification of final refined preferred alternative(s)

- Long-term (16-year) water quality modeling simulation runs of preferred alternative(s) including drought and wet years

- Selection of optimized final preferred alternative(s)

5.2.2 FINAL PILOT PROJECT DEVELOPMENT AND DESCRIPTION

Once the selection of a final preferred alternative is made, a final pilot project and full program should be developed and described. Development of the final pilot project and full program should follow an incremental analysis approach to ensure that the pilot project provides a progressive, phased-development to achieve the preferred alternative at a full program level. Next steps and information needs for final pilot project and full program development and description include the following:

< Final Pilot Project Development and Description—Incremental Approach Analysis (6 months)

- Evaluate and prioritize individual construction elements as pilot projects
    - Hydrodynamic and water quality modeling simulation runs of individual elements
        - Salinity, velocity, and stage change analysis
    - Objectives criteria screening of individual elements
    - Benefit-cost analysis (including weighted and operational)
    - Evaluate phased implementation effectiveness in achieving final comprehensive alternative program
- Develop monitoring, research, and adaptive management program(s), including evaluation (i.e., success) criteria, program schedule, and budget requirements
    - Monitor and study ecosystem response to advance knowledge of critical uncertainties
        - Egeria
        - Corbicula
        - DOC (ecosystem and drinking water quality considerations)
        - Mercury methylation
- Develop public stewardship outreach and education program
- Selection of pilot project(s) for implementation

5.2.3 PILOT PROJECT ENVIRONMENTAL COMPLIANCE AND IMPLEMENTATION

Once the selection of a final pilot project(s) has been made, environmental review, project design, and regulatory permitting activities should be initiated. Next steps and information needs for this phase include the following:

- Pilot project environmental review (CEQA/NEPA) (12 months)
- Pilot project preliminary design (4 months)
- Pilot project final design (7 months)
- Regulatory permitting (9 months)
- Pilot project construction (6 to 36 months)
- Pilot Project monitoring and evaluation (12 months)

5.2.4 FULL PROGRAM ENVIRONMENTAL COMPLIANCE AND IMPLEMENTATION

Once the final pilot project has been implemented, monitored, evaluated, and determined effective in demonstrating predicted results (to the extent implemented), environmental review, design, and regulatory permitting activities for the full program should be initiated. Next steps and information needs for this final phase include the following:

- Full program environmental review (CEQA/NEPA) (18 months)
- Full program preliminary design (6 months)
- Full program final design (12 months)
- Full program regulatory permitting (9 months)
- Full program construction (24 to 36 months)
- Full program monitoring and evaluation (36 months)

5.3 PILOT PROJECT

Once the final alternatives have been further refined and optimized, implementation of a final pilot project would be fully defined. Specification of phasing should include an incremental approach for achieving alternative implementation at a full program level. Likely considerations for selecting incremental pilot project actions include water quality improvement (and model testing), habitat value, ease of implementation, public visibility, adaptive management value, and availability of funding. NEPA/CEQA documentation should begin once the final alternative(s) and pilot action(s) have been selected. If multiple final pilot projects are brought forward, the CEQA/NEPA process would result in the selection of a preferred pilot project for implementation.

Regulatory approval of a pilot project would be facilitated, if it is designed to not cause any significant unavoidable effects on the environment, which, in turn, would avoid the need to prepare an EIR/EIS. Therefore, it is conceivable that a pilot project could be approved using an Initial Study/Mitigated Negative Declaration for CEQA compliance and Environmental Assessment/Finding of No Significant Effect for NEPA compliance. (Because of the magnitude of the full program, it would be expected to require an EIR/EIS for CEQA/NEPA compliance.)

Further, a programmatic EIR/EIS could be prepared that encompasses both a pilot project and full program implementation. Combining regulatory permitting for the pilot project and full program implementation could be done during this timeframe as well. This approach would likely result in cost and time savings provided the project is fully implemented.

5.3.1 PRELIMINARY PILOT PROJECT APPROACH

The pilot project components are proposed to be constructed as potential temporary facilities which can be installed at a minimal cost and removed if monitoring results (e.g., salinity changes, ecological response) determine it to be unsuccessful. If successful, the pilot project may become a permanent facility. The pilot facility will use construction materials which can be placed and removed in the most cost-effective manner. The pilot project may involve plans to make modifications in the pilot facilities and/or its operations to evaluate the response to various indicators such as salinity, Egeria, etc.

A monitoring plan for the pilot project will be developed to measure the performance of the improvements in achieving objectives and other potential effects it may have on the area. The results of the monitoring may also indicate the need to make modifications in the design and/or operation of the improvement element. An adaptive management approach may be implemented in the development and refinement of the project.

A preliminary approach for developing a pilot project is provided below. This approach identifies individual construction elements as the primary constituents for implementation plan development.

CONSTRUCTION ELEMENTS

The toolkit matrix (toolkit) introduced in Chapter 3 and refined and finalized in Chapter 4 details the construction elements comprising each of the preferred alternatives (Exhibit 5.3-1). The construction elements included in the toolkit are categorized in four broad categories, as follows:

- Flow Control Structures
- Pocket Beaches and Habitat
- Levee Restoration
- Marsh Creation on Little Franks Tract (LFT)

For each construction element identified above, separate pilot project implementation plans can be developed for a preferred alternative. The following discussion describes potential pilot project implementation plans for each construction element.

5.3.2 FLOW CONTROL STRUCTURES

PERMANENT CONSTRUCTION

The first two flow control structures identified in the toolkit—operable and non-operable gates—are envisioned as being constructed via float-in construction techniques, similar to how the Montezuma Slough Salinity Control Structure was constructed. The components of operable and non-operable flow control structures were broken into four items:

- Access Roads/Embankments
- Boat Lock Structure
- Flashboard Structure
- Salinity Control Structure

For an operable gate structure, the structure would be very similar to the Montezuma facility with the only exception being the number of gates. The number of gates would depend on the anticipated peak tidal flow the structure is required to pass while in operation.

The non-operable gate structure would consist of the first three elements (i.e., access roads/embankments; boat lock structure; and flashboard structure); however, the salinity control structure, composed of the operable radial gates, would be omitted. What would vary, therefore, is the length of the flashboard structure that would be dependent on the width of the channel wherein the facility is being constructed.

The flow control structures referred to as "constrictions" are envisioned as flow constraints placed across a channel so as to restrict the cross-sectional area of the channel, thus reducing the channel's capacity to pass flow. These have been assumed for the Pre-Feasibility Study to represent a reduction of approximately 50% in the cross-sectional channel area.

5.3.3 PILOT PROJECT CONSTRUCTION

For a potential pilot project, it would be necessary to demonstrate a particular flow control structure's capability to achieve its estimated water quality benefits before permanent construction of the element. Consequently, it is envisioned that potential pilot projects, designed to demonstrate the effectiveness of operable and non-operable gate structures, could be constructed as temporary rock barriers similar to those constructed by the Department of Water Resources (DWR) in Middle River and Old River.

At each location proposed, temporary facilities could be provided to facilitate the passage of small boats, similar to the operation currently employed by DWR at the other barriers (i.e., launch ramps on both sides of the barrier with State personnel on station to help portage boats around it). Additionally, to simulate the operation of gates, a series of large-diameter culverts equipped with flap gates could be provided. Each of these facilities could be removed either annually and/or at the conclusion of a specified period of monitoring before construction of the permanent improvements.

Considering the nature of the proposed channel constriction flow control structure element, it is envisioned the method of construction (e.g., rock) would not differ between pilot project and permanent construction.

POCKET BEACHES AND HABITAT

Because the proposed pocket beaches and habitat entail the creation of levee (either rock or concrete sheet pile) and placement of sand fill material for beach and habitat creation, pilot project demonstrations would require construction of the actual proposed project elements. However, the complete scope of a specific alternative's proposed elements could be constructed in a phased manner over a specified period. During the implementation period, benefits could be monitored and adaptive management employed for remaining features.

LEVEE RESTORATION

As with pocket beaches and habitat, the proposed levee restoration entails the creation of levee (either rock or concrete sheet pile) and placement of sand fill material for beach and habitat creation. Pilot demonstrations of this element would require construction of the actual proposed elements. However, the complete scope of a specific alternative's proposed elements could be constructed in a phased manner over a specified period. During the implementation period, benefits could be monitored and adaptive management employed for remaining features.

LITTLE FRANKS TRACT MARSH CREATION

The creation of tidal marsh habitat within LFT requires the partial restoration of the perimeter levee system for confinement of fill materials required to raise existing ground elevations within LFT to an elevation of approximately –0.5 NGVD. A pilot demonstration project of this element could be scaled as necessary to accommodate project needs.

Alternatively, it is possible that the perimeter levee system could be restored and the placement of fill material withheld pending confirmation (from monitoring) that anticipated water quality benefits are being realized.

5.3.4 PRELIMINARY PILOT PROJECT(S) DESCRIPTION

Preliminary pilot projects for each of the four preferred alternatives are provided below. Individual components for each preliminary project are identified to address each of the Pre-Feasibility Study objectives.

WEST FALSE RIVER GATE ALTERNATIVE

The pilot project for the West False River Gate alternative is composed of the following features: a temporary rock barrier with culverts and flap gates in False River and northwest pocket beach/marsh creation. Individually, the pilot project components identified for this alternative generally meet individual study objectives; however, when combined, these components meet all the study objectives. In addition to contributing to a phased approach to completion of the comprehensive alternative, all pilot project components have stand-alone benefits and/or benefits that would serve as preparation for implementation of subsequent long-term permanent elements. Recommended preliminary pilot project components for the West False River Gate Alternative are described below and presented in Exhibit 5.3-2. Cost estimates for preliminary pilot project components for the West False River Gate Alternative are detailed in Table 5.3-1.

Temporary Rock Barrier with Culverts and Flap Gates

A temporary rock barrier with culverts and flap gates could be installed in False River. It is recognized that constructing a temporary structure this large with the capacity to convey necessary False River flows may not be deemed feasible. This preliminary project would, however, prepare the site for a long-term permanent structure if the alternative were carried forward to full program-level implementation. The temporary rock barrier would compact the channel substrate and would provide the foundation base for a permanent operable barrier, thereby reducing future costs and efforts of subsequent phases.

Northwest Pocket Beach/Marsh Creation

A single northwest pocket beach/marsh area could be created along the existing north levee adjacent to False River. The pocket beach/marsh is relatively small and would provide habitat and recreational benefits. The beach would be built on the Franks Tract side of the levee within an existing cove. The tidal marsh would be adjacent to False River and provide benefits to several native fish species.

NORTH LEVEE AND TWO GATES ALTERNATIVE

The pilot project for the North Levee and Two Gates alternative is comprised of the following components: north setback levee creation, rock constrictions in Piper Slough, a cutoff at Horseshoe Bend with tidal marsh creation, and northwest pocket beach/marsh creation. As with the West False River Gate alternative, the pilot project components identified for this alternative generally meet study objectives and have stand-alone benefits and/or benefits that would serve as preparation for implementation of subsequent long-term permanent elements. Recommended preliminary pilot project components for the North Levee and Two Gates alternative are described below and presented in Exhibit 5.3-3. Cost estimates for preliminary pilot project components for the North Levee and Two Gates Alternative are detailed in Table 5.3-2.

North Setback Levee Creation

The north setback levee could be created along False River as a first phase before installation of temporary barriers or gates in the main nozzle or in Piper Slough. The setback levee would need to be completed before installation gates or barriers to stabilize the existing remnant levee

Table 5.3-1
West False River Gate Alternative – Pilot Project Components Cost Estimate

Description	Quantity	Unit	Unit Price	Sub-Total	Contingency @ 30%	Engineering / Legal / Administration @ 25%	Total
TEMPORARY ROCK BARRIER*							
Rock Barrier	800	lf	$4,222	$3,378,000	$1,013,000	$1,098,000	$5,489,000
Culverts with Flap Gates	28	ea	$15,000	$420,000	$126,000	$137,000	$683,000
Articulated Block Mat	4,320	sf	$9	$39,000	$12,000	$13,000	$64,000
Sub-Total				$3,837,000	$1,151,000	$1,248,000	$6,236,000
POCKET BEACHES/HABITAT							
Northwest Pocket Beach &Habitat	2,080	lf	$1,615	$3,359,000	$1,008,000	$1,092,000	$5,459,000
Sub-Total				$3,359,000	$1,008,000	$1,092,000	$5,459,000
TOTAL ALTERNATIVE COST				$7,196,000	$2,159,000	$2,340,000	$11,695,000
**Estimated Annual Cost of Barrier Removal (to - 15)*	*61,000*	*ton*	*$18*	*$1,098,000*	*$329,000*	*$357,000*	*$1,784,000*

Source: Moffat and Nichol 20

Table 5.3-2
North Levee and Two Gates Alternative - Pilot Project Components Cost Estimate

Description	Quantity	Unit	Unit Price	Sub-Total	Contingency @ 30%	Engineering / Legal / Administration @ 25%	Total
CLOSE NORTH LEVEE ON FRANKS TRACT							
Set-Back Levee Sta. 392+73 to 452+09	5,763	lf	$1,146	$6,604,000	$1,981,000	$2,146,000	$10,731,000
Jet Closure Sta. 378+93 to 392+73	1,532	lf	$1,540	$2,359,000	$708,000	$767,000	$3,834,000
Set-Back Levee Sta. 461+75 to 468+22	646	lf	$1,146	$740,000	$222,000	$241,000	$1,203,000
Jet Closure Sta. 452+09 to 461+75	1,060	lf	$1,626	$1,724,000	$517,000	$560,000	$2,801,000
Set-Back Levee Sta. 498+98 to 533+15	3,373	lf	$1,146	$3,865,000	$1,160,000	$1,256,000	$6,281,000
		Sub-Total		$15,292,000	$4,588,000	$4,970,000	$24,850,000
POCKET BEACHES/HABITAT							
Northwest Pocket Beach &Habitat	2,080	lf	$1,615	$3,359,000	$1,008,000	$1,092,000	$5,459,000
		Sub-Total		$3,359,000	$1,008,000	$1,092,000	$5,459,000
ROCK CONSTRICTIONS IN PIPER SLOUGH							
West Constriction	382	lf	$667	$255,000	$77,000	$83,000	$415,000
East Constriction	179	lf	$667	$119,000	$36,000	$39,000	$194,000
		Sub-Total		$374,000	$113,000	$122,000	$609,000
HORSESHOE BEND CUTOFF & TIDAL MARSH CREATION							
Rock Dike Levee Repair	4,894	lf	$572	$2,799,000	$840,000	$910,000	$4,549,000
Fill Placement (sourced within Franks Tract)	83,000	cy	$4	$332,000	$100,000	$108,000	$540,000
		Sub-Total		$3,131,000	$940,000	$1,018,000	$5,089,000
TOTAL ALTERNATIVE COST				$22,156,000	$6,649,000	$7,202,000	$36,007,000

Source: Moffat and Nichol 2005

and prevent increased erosion caused by greater water velocities resulting from barriers and/or gates. As a stand-alone feature, the levee would provide many benefits. Construction of the levee would stabilize the existing remnant and preserve the associated habitat values and hydrologic functions. Additionally, the setback levee would reduce wind-wave fetch and associated erosive forces on adjacent Webb Tract levees. Extensive tidal marsh habitat between the new setback and existing remnant levees (as well as additional beaches) could be created in conjunction with or as an additional phase to this pilot project.

Rock Constrictions in Piper Slough

Rock constrictions could be installed in Piper Slough to reduce flow volumes and velocities that currently pass through Horseshoe Bend. The outer levee of Horseshoe Bend has been identified as a problem area because of scouring and erosion and thus requires regular ongoing maintenance to prevent failure (Hultgren, pers. comm., 2005). Rock constrictions may reduce current scour and erosion rates and provide additional flood protection to Bethel Island while reducing long-term levee maintenance costs.

Horseshoe Bend Cutoff and Tidal Marsh Creation

The Horseshoe Bend cutoff would function in tandem with the rock constrictions in Piper Slough to potentially reduce flow volumes and velocities in the bend and thus reduce levee scour and erosion. In addition, the cutoff would create an island in Horseshoe Bend that could be used to create tidal marsh habitat. The tidal marsh habitat could be created through the importation of fill material or could serve as an experimental site for implementing the mud slurry/jacking technique described in Chapter 3.

Northwest Pocket Beach/Marsh Creation

A single northwest pocket beach/marsh area could be created in association with the north setback levee adjacent to False River. The pocket beach/marsh would provide the same habitat and recreational benefits as described above for West False River Gate alternative.

EAST LEVEE AND TWO GATES ALTERNATIVE

The pilot project for the East Levee and Two Gates alternative is composed of the following features: east setback levee creation with beach and marsh habitat, rock constrictions in Piper Slough, a cutoff at Horseshoe Bend with tidal marsh creation, and northeast pocket beach/marsh creation. As with the West False River Gate alternative, pilot project components identified for this alternative generally meet study objectives and have stand-alone benefits and/or benefits that would serve as preparation for implementation of subsequent long-term permanent elements. Recommended preliminary pilot project components for the East Levee and Two Gates alternative are described below and presented in Exhibit 5.3.4. Cost estimates for preliminary pilot project components for the East Levee and Two Gates Alternative are detailed in Table 5.3-3.

Table 5.3-3
East Levee and Two Gates Alternative - Pilot Project Components Cost Estimate

Description	Quantity	Unit	Unit Price	Sub-Total	Contingency @ 30%	Engineering / Legal / Administration @ 25%	Total
CLOSE EAST LEVEE ON FRANKS TRACT							
Set-Back Levee Sta. 268+69 to 295+90	2,778	lf	$1,146	$3,184,000	$955,000	$1,035,000	$5,174,000
Set-Back Levee Sta. 295+90 to 325+42	2,956	lf	$1,447	$4,277,000	$1,283,000	$1,390,000	$6,950,000
Set-Back Levee Sta. 325+42 to 355+00	2,948	lf	$1,146	$3,378,000	$1,013,000	$1,098,000	$5,489,000
			Sub-Total	$10,839,000	$3,251,000	$3,523,000	$17,613,000
POCKET BEACHES/HABITAT							
Northeast Pocket Beach & Habitat	2,316	lf	$1,575	$3,648,000	$1,094,000	$1,186,000	$5,928,000
			Sub-Total	$3,648,000	$1,094,000	$1,186,000	$5,928,000
ROCK CONSTRICTIONS IN PIPER SLOUGH							
West Constriction	382	Lf	$667	$255,000	$77,000	$83,000	$415,000
East Constriction	179	Lf	$667	$119,000	$36,000	$39,000	$194,000
			Sub-Total	$374,000	$113,000	$122,000	$609,000
HORSESHOE BEND CUTOFF & TIDAL MARSH CREATION							
Rock Dike Levee Repair	4,894	Lf	$572	$2,799,000	$840,000	$910,000	$4,549,000
Fill Placement (sourced within Franks Tract)	83,000	Cy	$4	$332,000	$100,000	$108,000	$540,000
			Sub-Total	$3,131,000	$940,000	$1,018,000	$5,089,000
TOTAL ALTERNATIVE COST				$17,992,000	$5,398,000	$5,849,000	$29,239,000

Source: Moffat and Nichol 2005

East Setback Levee Creation

The east setback levee would be created along Old River as a first phase before installation of temporary barriers or gates in east False River or Sand Mound Slough. As with the North Levee and Two Gates alternative, the levee would need to be completed before gate or barrier implementation to stabilize the existing levee remnants, prevent increased erosion caused by greater water velocities resulting from barriers and/or gates, and to maintain hydrologic function in the Old River channel. As with the North Levee and Two Gates alternative, the levee would provide many benefits as a stand-alone feature. Construction of the levee would stabilize the existing remnant and subsequently preserve the associated habitat values and hydrologic functions. Additionally, the setback levee would reduce wind-wave fetch and associated erosive forces on adjacent Mandeville Island levees. Tidal marsh habitat and beach areas adjacent to the new setback levee could be created in conjunction with or as an additional phase to this pilot project component.

Northeast Pocket Beach/Marsh Creation

A single northeast pocket beach/marsh area could be created as an extension of the east setback levee. The pocket beach/marsh would provide the same habitat and recreational benefits as described above for the West False River Gate alternative and would also provide incremental benefits if the alternative were to be carried forward to full program-level implementation.

Rock Constrictions in Piper Slough

As with the North Levee and Two Gates alternative, rock constrictions could be installed in Piper Slough to reduce flow volumes and velocities that currently pass through Horseshoe Bend and thus may provide additional flood protection while reducing long-term levee maintenance costs.

Horseshoe Bend Cutoff and Tidal Marsh Creation

The cutoff at Horseshoe Bend and tidal marsh creation would function in the same manner and provide the same benefits as explained above for the North Levee and Two Gates alternative.

COX ALTERNATIVE

The pilot project for the Cox Alternative is composed of the following features: temporary rock barriers in Old River and Holland Cut, and northwest pocket beach/marsh creation. As with the West False River Gate alternative, the pilot project components identified for this alternative generally meet study objectives and have stand-alone benefits and/or benefits that would serve as preparation for implementation of subsequent long-term permanent elements. Recommended preliminary pilot project components for the Cox alternative are described below and presented in Exhibit 5.3-5. Cost estimates for preliminary pilot project components for the Cox Alternative are detailed in Table 5.3-4.

Table 5.3-4
Cox Alternative - Pilot Project Components Cost Estimate

Description	Quantity	Unit	Unit Price	Sub-Total	Contingency @ 30%	Engineering / Legal / Administration @ 25%	Total
TEMPORARY ROCK BARRIER IN OLD RIVER*							
Rock Barrier	860	lf	$2,256	$1,940,000	$582,000	$631,000	$3,153,000
Culverts w/Flap Gates	13	ea	$15,000	$195,000	$59,000	$64,000	$318,000
Articulated Block Mat	4,320	sf	$9	$39,000	$12,000	$13,000	$64,000
			Sub-Total	$2,174,000	$653,000	$708,000	$3,535,000
TEMPORARY ROCK BARRIER IN HOLLAND CUT*							
Rock Barrier	640	lf	$2,641	$1,690,000	$507,000	$549,000	$2,746,000
Culverts w/Flap Gates	13	ea	$15,000	$195,000	$59,000	$64,000	$318,000
Articulated Block Mat	4,320	sf	$9	$39,000	$12,000	$13,000	$64,000
			Sub-Total	$1,924,000	$578,000	$626,000	$3,128,000
POCKET BEACHES/HABITAT							
Northwest Pocket Beach & Habitat	2,080	lf	$1,615	$3,359,000	$1,008,000	$1,092,000	$5,459,000
Sub-Total				$3,359,000	$1,008,000	$1,092,000	$5,459,000
TOTAL ALTERNATIVE COST				$7,457,000	$2,239,000	$2,426,000	$12,122,000
**Estimated Annual Cost of Barrier Removal (to -15)*	*54,000*	*ton*	*$18*	*$972,000*	*$292,000*	*$316,000*	*$1,580,000*

Source: Moffat and Nichol 2005

Temporary Rock Barriers with Pipes and Flap Gates in Holland Cut and Old River

Temporary rock barriers could be installed in Old River and Holland Cut. As with the West False River Gate alternative, this preliminary pilot project component would prepare the site for a long-term permanent structure if the alternative were carried forward to full program-level implementation. The temporary rock barrier would compact the channel substrate and would provide the foundation base for a permanent operable barrier, thereby, reducing future costs and efforts of subsequent phases.

Northwest Pocket Beach/Marsh Creation

A single northwest pocket beach/marsh area could be created along the north remnant levee adjacent to False River. The pocket beach/marsh would provide the same habitat and recreational benefits as described above for the West False River Gate alternative.

PILOT PROJECTS COST SUMMARY

Summary comparison cost estimates for the preliminary pilot projects are detailed below (Table 5.3-5) (Exhibit 5.3-6).

5.4 ENVIRONMENTAL REVIEW AND PERMITTING

Implementation of an alternative would be considered a "project" under the California Environmental Quality Act (CEQA) and a "major federal action" as defined in the National Environmental Policy Act (NEPA) and, thus, would require review of the project's environmental impacts in compliance with both CEQA and NEPA. Additional permitting and regulatory compliance processes in accordance with other federal and state laws and regulations would also be required.

The following actions may be required, depending on the types of site concepts involved in a project and their potential physical effects.

5.4.1 ENVIRONMENTAL COMPLIANCE (NEPA AND CEQA)

As mentioned, projects resulting from the Feasibility Study, including pilot projects, would require CEQA and potentially NEPA environmental review, because the projects would be expected to result in changes to the physical environmental (e.g., levee modifications and resulting changes in salinity regime). Because of the environmental changes could be substantial, an Environmental Impact Report (EIR) for CEQA purposes and an Environmental Impact Statement (EIS) for NEPA purposes (if required) would probably be prepared for full implementation of one of the alternatives; these two reports can be combined in a joint document. However, potential pilot projects, if designed to not cause any significant unavoidable effects on the environment, may avoid the need to prepare an EIR/EIS.

Table 5.3-5
Flooded Island Pre-Feasibility Study Preliminary Pilot Projects Summarized Cost Estimate

Description	Quantity	Unit	Unit Price	Sub-Total	Contingency @ 30%	Engineering / Legal / Administration @ 25%	Total Cost
WEST FALSE RIVER GATE ALTERNATIVE – PILOT PROJECT							
Temporary Rock Barrier*	1	ls	$3,837,000	$3,837,000	$1,151,000	$1,247,000	$6,235,000
Pocket Beaches/Habitat	12.5	acres	$268,720	$3,359,000	$1,008,000	$1,092,000	$5,459,000
TOTAL COST				$7,196,000	$2,159,000	$2,339,000	$11,695,000
NORTH LEVEE AND TWO GATES ALTERNATIVE - PILOT PROJECT							
Close North Levee On Franks Tract	12,374	lf	$1,236	$15,292,000	$4,588,000	$4,970,000	$24,850,000
Pocket Beaches/Habitat	12.5	acres	$268,720	$3,359,000	$1,008,000	$1,092,000	$5,459,000
Rock Constrictions In Piper Slough	2	ea	$187,000	$374,000	$112,000	$122,000	$608,000
Horseshoe Bend Cutoff & Tidal Marsh Creation	12.5	acres	$250,480	$3,131,000	$939,000	$1,018,000	$5,088,000
TOTAL COST				$22,156,000	$6,647,000	$7,202,000	$36,005,000
EAST LEVEE AND TWO GATES ALTERNATIVE – PILOT PROJECT							
Close East Levee On Franks Tract	8,682	lf	$1,248	$10,839,000	$3,252,000	$3,523,000	$17,614,000
Pocket Beaches/Habitat	14.0	acres	$260,571	$3,648,000	$1,094,000	$1,186,000	$5,928,000
Rock Constrictions In Piper Slough	2	ea	$187,000	$374,000	$112,000	$122,000	$608,000
Horseshoe Bend Cutoff & Tidal Marsh Creation	12.5	acres	$250,480	$3,131,000	$939,000	$1,018,000	$5,088,000
TOTAL COST				$17,992,000	$5,397,000	$5,849,000	$29,238,000
COX ALTERNATIVE – PILOT PROJECT							
Temporary Rock Barrier In Old River*	1	ls	$2,174,000	$2,174,000	$652,000	$707,000	$3,533,000
Temporary Rock Barrier In Holland Cut*	1	ls	$1,924,000	$1,924,000	$577,000	$625,000	$3,126,000
Pocket Beaches/Habitat	12.5	acres	$268,720	$3,359,000	$1,008,000	$1,092,000	$5,459,000
TOTAL COST				$7,457,000	$2,239,000	$2,426,000	$12,122,000

Source: Moffat and Nichol 2005

Therefore, it is conceivable that a pilot project could be approved using an Initial Study/ Mitigated Negative Declaration (IS/MND) for CEQA compliance and Environmental Assessment/Finding of No Significant Effect (EA/FONSI) for NEPA compliance. Alternatively, a programmatic EIR/EIS could be prepared that encompasses both a pilot project and full program implementation. Additionally, separate or combined regulatory permit applications and processes for the pilot project and full program implementation could be carried out, as well. A key question would be the relative schedule for implementation of the pilot project and full program. If the time between the two projects is substantial, separate permitting may be warranted. If the full program implementation follows closely behind the pilot project, a combined permitting process could be pursued. The latter approach would likely result in overall cost and time savings provided the program is fully implemented. The following is a description of conceptual steps required for a joint CEQA/NEPA review that assumes an EIR/EIS as the required document.

Projects resulting from the Feasibility Study would include improvements that are specifically designed to meet California Bay-Delta Authority (CBDA, formerly CALFED) water quality and ecosystem restoration goals and objectives, and the participating funding and regulatory review agencies would likely require the projects be generally compliant and consistent with related CBDA action compliance procedures. In addition, mitigation measures must be considered and adopted, where appropriate, that are consistent with those mitigation strategies adopted and identified in Appendix A of the CALFED Programmatic Record of Decision (ROD) (CALFED 2000). For these reasons, such projects are considered CBDA actions. CBDA's Guide to Regulatory Compliance for Implementing CALFED Actions (CALFED 2002) states that CEQA compliance for actions undertaken for CBDA's Preferred Program Plan be tiered from the CALFED Final EIS/EIR. However, the Feasibility Study was not specifically identified as part of the CALFED program when the EIS/EIR was prepared. Thus, the environmental effects of the projects resulting from the Feasibility Study were not evaluated. For this reason, the EIS/EIR for projects resulting from the Feasibility Study may not be suitable for tiering under the Programmatic EIS/EIR.

Regardless of whether the EIR/EIS would be a tiering document or not, the following conceptual steps would be required for a joint CEQA/NEPA review.

IDENTIFICATION OF LEAD AGENCIES

An important initial step in the EIR/EIS process would be to confirm the determination of state and federal agencies involved in the process.

For the purposes of CEQA compliance, a lead agency, which would have the principal responsibility for carrying out or approving the project, would need to be identified. Several agencies are involved in the development of the Feasibility Study, and each phase of the Feasibility Study, including subsequent actions, differs in terms of the primary funding agency. Furthermore, each of the Flooded Islands is owned and managed by different agencies. Because DWR has been the agency that spearheaded the Feasibility Study and is expected to implement the subsequent action, DWR may serve as the lead agency for CEQA purposes. The other agencies with discretionary approval authority (e.g., funding, permitting, land use), including State Reclamation Board, Department of Fish and Game, Department of Parks and Recreation, Metropolitan Water District, and Contra Costa Water District, would serve as responsible agencies and/or trustee agencies.

If congressional funding is used for the project, the NEPA lead agency could be the U. S. Bureau of Reclamation. The other potential lead agency may the U. S. Army Corps of Engineers (USACE), as a result of either funding or Section 404/Section 10 authorizations needed for the project, or USACE may be a cooperating agency. Other federal agencies with authority over the project may be designated as cooperating agencies, such as the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries).

NOTICE OF PREPARATION AND NOTICE OF INTENT

The public review process begins with the Notice of Preparation (NOP), for CEQA purposes, and Notice of Intent (NOI), for NEPA purposes. It would contain a draft project description and a discussion of issues for which no significant impacts will occur (therefore needing no additional consideration) and of topics that require further evaluation in the EIR/EIS. The NOP/NOI would be distributed to all cooperating agencies, responsible agencies, and organizations and members of the public that have expressed interest in the project. The NOP/NOI would also be posted in publications and at the project site. Members of the public, organizations, and agencies can submit responses to the NOP/NOI, including comments about the project and issues they would like addressed. The responses may be submitted in the form of letters, email, and other written correspondences or as verbal comments given in public scoping meeting(s) for the project.

DRAFT EIR/EIS

Once the NOP/NOI process is complete, a Draft EIR/EIS would be prepared. This document would contain a project description, which would contain discussion of: regional and local setting; planning context; the current status of important related projects and environmental studies; objectives of the proposed project; project characteristics, including a description of the project options and alternatives, site plan, and other applicable project plans; and intended uses of the EIR/EIS, including lists of responsible agencies and approvals for which the EIR/EIS will be used. The description of alternatives would be another important component of the EIR/EIS. Other components of the Draft EIR/EIS would be an introduction and summary; affected environment, environmental consequences, and mitigation measures for potentially significant environmental issues; assessment of cumulative and growth-inducing impacts; significant and unavoidable adverse impacts; significant irreversible environmental changes; alternatives analysis; and other CEQA- and NEPA-mandated sections. The Draft EIR/EIS would include analyses and determination of the significance of environmental impacts, as well as mitigation measures for significant impacts, if feasible. The Draft EIR/EIS would be distributed to agencies and the public for a 45- to 60-day review period. Comments on the Draft EIR/EIS may be submitted to the lead agencies during this review period for consideration in the Final EIR/EIS.

FINAL EIR/EIS AND MITIGATION MONITORING PROGRAM

The Final EIR/EIS would contain written responses to comments received on the Draft EIR/EIS, as well as revisions to the Draft EIR/EIS. The Final EIR/EIS would be distributed to public agencies for 10 days prior to the certification of the EIR, and made available to the public, as required by the NEPA lead agency.

A Mitigation Monitoring Program (MMP) would be prepared concurrently with the preparation of the Final EIR/EIS. The MMP, which would list responsible parties, monitoring parties, and timing associated with each mitigation measure, would ensure compliance with adopted mitigation requirements during project implementation.

FINDINGS/STATEMENT OF OVERRIDING CONSIDERATIONS/RECORD OF DECISION/NOTICE OF DETERMINATION

A finding for each significant effect identified in the EIR/EIS and a Statement of Overriding Considerations, if significant unavoidable adverse impacts would occur, would be prepared. A Record of Decision would be adopted by the NEPA lead agency and Notice of Determination by the State lead agency.

5.4.2 PERMITTING AND REGULATORY ENVIRONMENT

Potential project constraints include sensitive biological resources that are protected and/or regulated by federal, state, and/or local laws and policies. In order for the project to be in compliance with federal, state, and local requirements, permits and/or authorizations would need to be obtained from the appropriate regulatory agencies. This section briefly summarizes background permit information but is focused specifically on permitting needs of the proposed pilot project or full implementation program. This section will serve as a guide to identify the required permits and authorizations, therefore minimizing permitting delays. As noted in Section 5.4.1, CEQA and potentially NEPA would be required for the proposed project. Early identification of the permit requirements will facilitate the use of the CEQA and potentially NEPA documents as supporting documents for the permit applications. Before implementation, it would be necessary for the preferred project alternative to be in compliance with the following regulations and permit requirements.

FEDERAL REGULATORY ISSUES

Clean Water Act

USACE regulates the placement of dredged or fill material into waters of the United States, under Section 404 of the Clean Water Act (CWA). Waters of the United States include lakes, streams, and their tributaries and adjacent wetlands. Wetlands are defined under Section 404 as areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support (and does support under normal circumstances) a prevalence of vegetation typically adapted to life in saturated soil conditions. Franks Tract, Little Franks Tract, False River, Old River, Piper Slough, Sand Mound Slough, and Holland Cut, are considered potentially jurisdictional waters of the United States. Activities that require a permit under Section 404 include, but are not limited to, placing fill or riprap, grading, mechanized land clearing, and dredging in waters of the United States. Any activity that results in the deposit of dredged or fill material within the ordinary high water mark of waters of the United States usually requires a permit, even if the area is dry when the activity takes place. Some activities that result in minor impacts to waters of the United States (e.g., 0.5 acres or less) may qualify under a USACE nationwide permit. If the project does not qualify for a nationwide permit, the applicant must obtain an individual permit.

The CWA and guidelines outlined in a memorandum of agreement (MOA) between the Environmental Protection Agency and USACE dated November 15, 1989, set forth a goal of restoring and maintaining existing aquatic resources. This MOA directs USACE to strive to avoid adverse impacts and offset unavoidable adverse impacts to existing aquatic resources, and for wetlands, to strive to achieve a goal of no overall net loss of values and functions. The MOA also noted the value of other waters of the United States, including streams, rivers, and lakes. Under the guidelines, all jurisdictional waters of the United States are afforded protection and requirements for practicable mitigation based on values and functions of the aquatic resources that will be affected.

Under Section 401of the CWA, an applicant for a Section 404 permit (to discharge dredged or fill material into waters of the United States) must obtain a certificate from the appropriate state agency stating that the fill of waters of the state is consistent with state water quality standards and criteria. In California, the authority to grant water quality certification is delegated by the State Water Resources Control Board (SWRCB) to nine regional boards. The project site is within the jurisdiction of the Central Valley Regional Water Quality Control Board (Central Valley RWQCB).

Clean Water Act Section 301-NPDES Construction Activity Stormwater Permits

The Central Valley Regional Water Board, under authority of the state Porter-Cologne Water Quality Control Act and pursuant to the federal Clean Water Act, is responsible for authorizing activities that have the potential to discharge wastes to surface or groundwater resources. Projects with construction activity that disturb greater than 1 acre of land are subject to the National Pollutant Discharge Elimination System (NPDES) stormwater permit for general construction activity (Order No. 99-08-DWQ). The NPDES permit requires filing of a Notice of Intent (NOI) to discharge stormwater to the Regional Water Board and preparation and implementation of a Storm Water Pollution Prevention Plan (SWPPP) to control contaminated runoff from temporary construction activities. The SWPPP provides the plans and specifications for erosion and sediment Best Management Practices (BMPs), means of waste disposal, implementation of approved local plans, post-construction sediment and erosion control BMPs and maintenance responsibilities, non-stormwater management BMPs, and BMP performance inspection requirements. The NPDES regulations require implementation of appropriate hazardous materials management practices to reduce the possibility of chemical spills or releases of contaminants, including any non-stormwater discharge to drainage channels. The NPDES regulations also require applicants to consider implementation of permanent post-construction BMPs to minimize operations-related long-term stormwater runoff effects. Monitoring provisions in the permit were modified pursuant to a court order in 2001 that require water quality sampling be conducted at construction sites if stormwater would discharge to a water body that is identified on a 303(d) list as impaired by sediment, silt, or turbidity. The revision, and revised guidance issued by the SWRCB, also requires SWPPPs to include visual inspection and monitoring protocols for nonvisible pollutants (i.e., contaminants known to occur on the construction site and that can not be visually observed or detected in storm water).

California Porter-Cologne Water Quality Control Act Compliance for Dredging

Authorization for sediment dredging and fill placement projects in the Delta requires several permits and authorizations. Permits for dredging are generally needed from the USACE, Central Valley Regional Water Board, and DFG. Dredging projects in the Delta also typically require review and consultation with USFWS, NOAA Fisheries, and DFG for potential effects on listed species under the federal and state Endangered Species Act regulations. Dredging in the Delta, and/or land disposal of dredge material, is typically restricted to certain “windows” in the late summer and early fall to avoid impacts to these species and to critical habitat. Cities and counties often have land use restrictions, or ordinances and restrictions for noise and scenic resource impacts that may affect project construction.

The Regional Water Board’s authority and requirements to issue Water Quality Certifications under Section 401 of the federal Clean Water Act and Waste Discharge Requirements (WDRs) under California’s Porter-Cologne Water Quality Control Act is a primary permitting process that largely influences the specific dredging and dredge material disposal actions that will be allowable. The applicant, or its designated general contractor[s], prepares a pre-dredge sampling and analysis plan (SAP) that identifies test protocols that will be used to evaluate the presence of contaminant that may impact water quality in the following pathways:

< in-stream impacts during dredging,

< direct exposure to contaminants in the material through ingestion, inhalation or dermal exposure,

< effluent (return flow) discharge from an upland disposal site, and

< leachate from upland dredge material disposal that may affect groundwater or adjacent surface water.

The dredge material and receiving water test results are evaluated to determine whether sediment is classified as “inert”, “designated”, or “hazardous” waste and the potential for dredging or dredge material disposal to exceed applicable water quality standards. The classification of the material is a principal factor that governs the specific dredging and disposal practices, and associated protection measures necessary for the project to proceed. WDRs are issued following completion of a certified CEQA document and must be approved by the Regional Water Board's Directors.

Section 10 of the Rivers and Harbors Act

USACE jurisdiction under the federal Rivers and Harbors Act of 1899 is limited to those activities affecting the navigable waters of the United States. Navigable waters of the United States are defined as those waters subject to the ebb and flow of the tide shoreward to the mean high-water mark and/or those that are presently used, have been used in the past, or may be susceptible to use to transport interstate or foreign commerce.

Proposed actions to construct or modify structures in or affecting navigable waters of the United States require authorization under Section 10 of the Rivers and Harbors Act. Authorization under Section 10 is typically required for actions involving any canal or artificial waterway proposed to be connected to navigable waters or affecting navigable waters during construction or operation in a manner that alters the course, location, condition, or capacity of these waters. Proposed actions involving tunneling or boring under navigable waters also require authorization under Section 10. USACE Section 10 authorization of the Rivers and Harbors Act would be required for the proposed project alternatives because it is assumed that building setback levees and/or installation of tidal gates would alter the course of the affected rivers and/or sloughs during high flow events.

Federal Endangered Species Act

Pursuant to the federal Endangered Species Act (ESA), USFWS and NOAA Fisheries have authority over projects that may affect the continued existence of federally listed fish and wildlife species. Section 9 of ESA and federal regulations prohibit the "take" of federally listed species. Take is defined under ESA, in part, as killing, harming, or harassment of such species. Under federal regulations, take is defined further to include habitat modification or degradation where it actually results, or is reasonably expected to result in, death or injury to wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

For all of the proposed project alternatives, federal consultation under Section 7 of ESA would be required if USACE or another federal agency authorizing or funding the project determined that it may affect a federally listed species. Section 7 of ESA outlines procedures for federal interagency cooperation to conserve federally listed species and designated critical habitat. ESA mandates that all federal agencies participate in the conservation and recovery of listed threatened and endangered species and that each agency ensure that any action they authorize, fund, or carry out does not jeopardize the continued existence of a listed species or its critical habitat. Critical habitat identifies specific areas that have the physical and biological features that are essential to the conservation of a listed species, and that may require special management considerations for protection. Because it is expected that all of the proposed project alternatives would require a permit from USACE to place fill in a waters of the United States and may affect federally listed species, USACE is expected to serve as the federal lead agency.

As part of the Section 404 process, a biological assessment will likely need to be prepared pursuant to Section 7 of ESA. A biological assessment evaluates the effects of a project on listed and proposed threatened and endangered species. The biological assessment would be submitted to USACE as the federal lead agency. USACE would then make a "no effect" or "may affect" determination if the project would affect a listed threatened or endangered species. Based on this determination, USACE will initiate Section 7 consultation through the request to USFWS and NOAA of a "not likely to adversely affect" concurrence or issuance of a biological opinion. If a "may affect" determination is made by the USFWS and/or NOAA Fisheries, the agency then prepares a biological opinion (BO) stating whether the project would jeopardize the continued existence of the species. If the federal lead agency does not concur with the findings in the biological opinion, they may request further discussion to resolve the issue. The BO may authorize a certain level of incidental take, contingent upon the implementation of specified terms and conditions to minimize such take and mitigate for its effects.

If CBDA funding is utilized for project implementation, the Action Specific Implementation Plan (ASIP) process could be initiated for compliance with ESA rather that the above described Section 7 process. With respect to regulatory permits at the project level, CBDA participant agencies developed and adopted programmatic environmental compliance agreements in the CBDA ROD that should be considered when seeking project-level compliance with the applicable regulatory requirement. Such programmatic compliance agreements were developed for the following:

- Clean Water Act Section 404,
- Rivers and Harbors Act Section 10 Memorandum of Understanding,
- Conservation Agreement Regarding Multi-Species Conservation Strategy (MSCS),
- Programmatic Endangered Species Act (ESA) Section 7 Biological Opinions,
- Natural Community Conservation Plan (NCCP) Determination, and
- Clean Water Act Section 401 MOU.

Project-level applicants should consult with the agency administering the regulatory requirement to determine if project-level compliance is required to comply with commitments made at the programmatic level, and in order to determine if the ASIP process is applicable to the project for ESA and NCCP compliance. If the project has the potential to affect listed species, an ASIP should be prepared for all listed species covered by the MSCS.

STATE REGULATORY ISSUES

California Endangered Species Act

Pursuant to the California Endangered Species Act (CESA), a permit from the California Department of Fish and Game (DFG) is required for projects that could take a species state listed as threatened or endangered. Section 2080 of CESA prohibits take of state listed species. Under CESA, take is defined as any activity that would directly or indirectly kill an individual of a species. The definition does not include “harm” or “harass” as in the federal act. As a result, the threshold for take under CESA is higher than under ESA (i.e., habitat modification is not necessarily considered take under CESA). The take of state-listed species incidental to otherwise lawful activities requires a permit, pursuant to Section 2081(b) of CESA. The state has the authority to issue an incidental take permit under Section 2081 of the DFG Code or to coordinate with USFWS during the federal process to make the federal permit also apply to state-listed species. Because all project alternatives have the potential to affect state-listed species (e.g., delta smelt), consultation with DFG would be required.

Section 1602 of the California Fish and Game Code—Streambed Alteration Agreement

All diversions, obstructions, or changes to the natural flow or bed, channel, or bank of any river, stream, or lake in California that supports fish or wildlife resources is subject to regulation by DFG in accordance with DFG Code Sections 1600–1616. Section 1602 states that it is unlawful for any governmental agency, state, or local or any public utility to substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake or use any material from the bed, bank, or channel of any river, stream, or lake, or deposit or dispose of debris, wastes, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake without first notifying DFG of such activity. The regulatory definition of a stream is a body of water that flows at least periodically or intermittently through a bed or channel having banks and supports wildlife, fish, or other aquatic life. This includes watercourses having a surface or subsurface flow that support or have supported riparian vegetation. Franks Tract, Little Franks Tract, False River, Old River, Piper Slough, Sand Mound Slough, and Holland Cut would all be regulated by DFG under Section 1602 of the DFG Code. All riparian habitat adjacent to these river and/or slough channels, and aquatic resources within the channel are also regulated under Section 1602.

DFG’s jurisdiction within altered or artificial waterways is based on the value of those waterways to fish and wildlife. A DFG Streambed Alteration Agreement must be obtained for any project that would result in a diversion, obstruction, or change on a river, stream, or lake. It is anticipated that a Streambed Alteration Agreement would be required for all of the proposed project alternatives because it is assumed that construction of setback levees and/or installation of tidal gates would cause a change in the river channel that may alter the bed and bank of the rivers and/or sloughs.

State Lands Commission Land Use Lease

The State Lands Commission (Commission) has jurisdiction and management control over those public lands of the State received by the State upon admission to the U.S. in 1850 (sovereign lands). Generally, these sovereign lands include all ungranted tideland and submerged lands, beds of navigable rivers, streams, lakes, bays, estuaries, inlets, and straits. The Commission manages sovereign lands for the benefit of all people of the State, subject to the public trust for water-related commerce, navigation, fisheries, recreation, open space, and other recognized public trust uses. The Commission Land Management Division administers the surface leasing of these lands, sand and gravel extraction from these lands, and dredging or disposal of dredge material on these lands.

For tidal waters, the Commission's jurisdiction extends to the ordinary high water mark. For nontidal waters, their jurisdiction extends to the ordinary low water mark. Typically, the Commission does not take jurisdiction over artificial waterways (e.g., reservoirs) only over natural bodies of water. Most activities occurring within these jurisdictional areas require a lease agreement with the Commission. Because all four project alternatives involve construction within land under the jurisdiction of the Commission, a State Lands Lease Agreement would be required.

State Reclamation Board Encroachment Permit

The State Reclamation Board has jurisdiction over any activity that has the potential to affect state or federal authorized flood control work in the Sacramento and San Joaquin Valleys. Any proposed activity along or near federal flood control project levees or in designated floodways requires a permit from the State Reclamation Board before the start of any construction activities within the floodway. Because all four project alternatives have the potential to affect flood control work, it is likely the applicant would be required to obtain and encroachment permit.

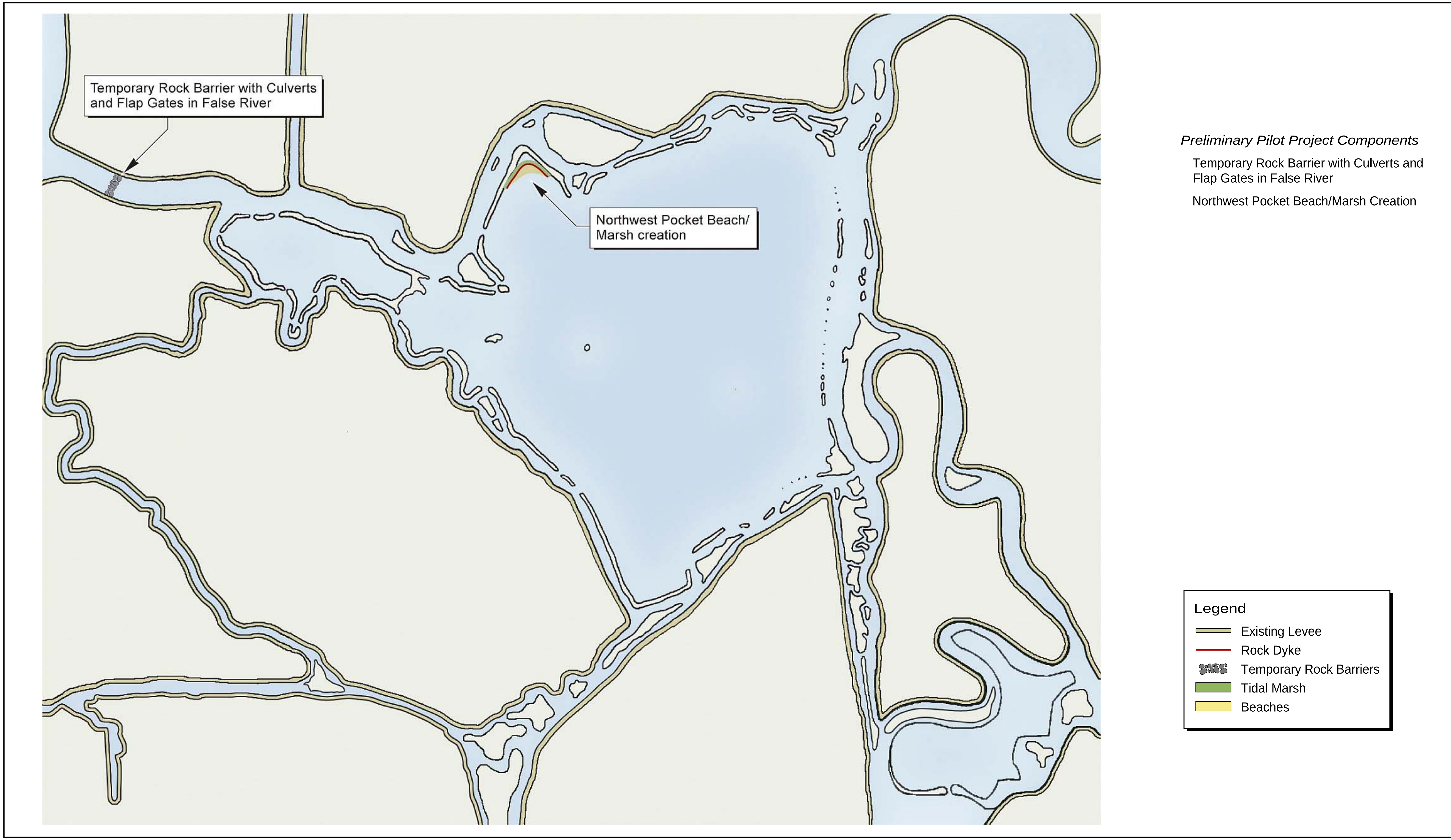
SUMMARY

Based on the current level of design detail, all of the project alternatives would require the following permits from the regulatory agencies: CWA Section 404, 401, and 301; Rivers and Harbors Act Section 10; ESA Section 7; CESA Section 2081 or 2080.1; DFG Section 1602; State Lands Lease; and a Reclamation Board encroachment permit. Because all alternatives contain the same three project components (i.e., restoration, recreation, and water quality), they all have the potential to be self mitigating.

			Alternative			
			West False River Gate	North Levee and Two Gates	East Levee and Two Gates	Cox
Non-Operable Gates						2-ea
Operable Gates			1-ea	2-ea	2-ea	
Flow Constrictions				3-ea	2-ea	
Pocket Location	West (60.3-acres)	Habitat	-included within the LFT marsh-			
		Beach				
	Northwest (12.5 - acres)	Habitat	3.9-acres	3.9-acres	3.9-acres	3.9-acres
		Beach	8.6-acres	8.6-acres	8.6-acres	8.6-acres
	Northeast (14.0-acres)	Habitat	4.4-acres	4.4-acres	4.4-acres	4.4-acres
		Beach	9.6-acres	9.6-acres	9.6-acres	9.6-acres
	East (12.9-acres)	Habitat	4.3-acres	4.3-acres	4.3-acres	4.3-acres
		Beach	8.6-acres	8.6-acres	8.6-acres	8.6-acres
	South (22.9-acres)	Habitat	5.5-acres	5.5-acres	5.5-acres	5.5-acres
		Beach	17.4-acres	17.4-acres	17.4-acres	17.4-acres
	Sub-Total (acres)	Habitat	18.1-acres	18.1-acres	18.1-acres	18.1-acres
		Beach	44.2-acres	44.2-acres	44.2-acres	44.2-acres
Levee Restoration	North Levee	Habitat		42.9-acres		
		Beach		0.0-acres		
	East Levee	Habitat			35.3-acres	
		Beach			11.2-acres	
Little Franks Marsh Creation			420-acres	420-acres	420-acres	420-acres
TOTAL HABITAT DEVELOPED			438-acres	481-acres	473-acres	438-acres
TOTAL BEACH DEVELOPED			44-acres	44-acres	55-acres	44-acres

Source: Moffat and Nichol 2005

Exhibit 5.3-1
Flooded Islands Pre-Feasibility Study Toolkit Matrix



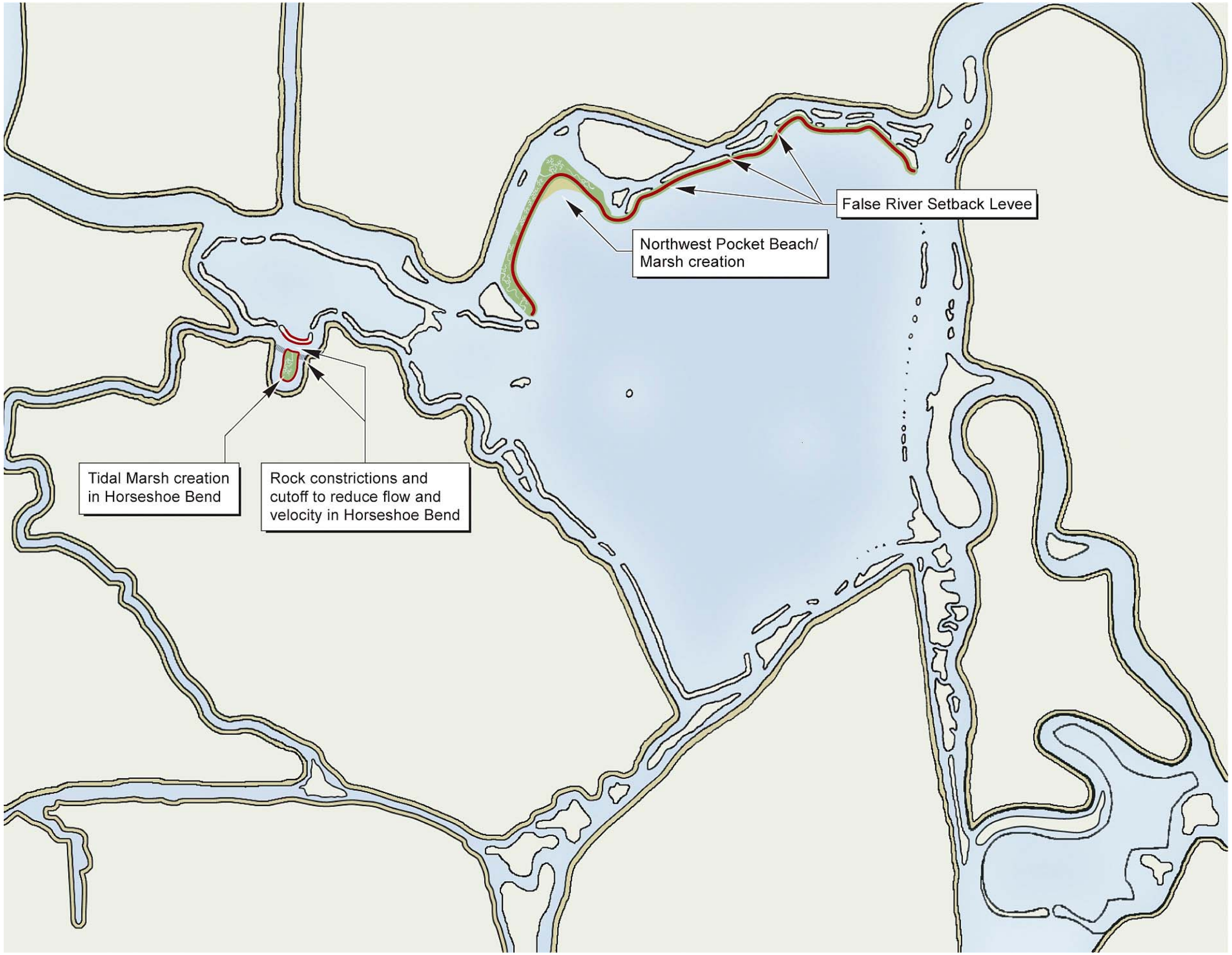
Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

West False River Gate Alternative—Preliminary Pilot Project Components

EXHIBIT 5.3-2

0 1500 3000
FEET
NORTH

EDAW



Preliminary Pilot Project Components

North (False River) Setback Levee Creation

Rock Constrictions in Piper Slough

Horseshoe Bend Cutoff and Tidal Marsh Creation

Northwest Pocket Beach/Marsh Creation

Legend

- Existing Levee
- Rock Dyke
- Rock Constrictions
- Tidal Marsh
- Beaches

Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

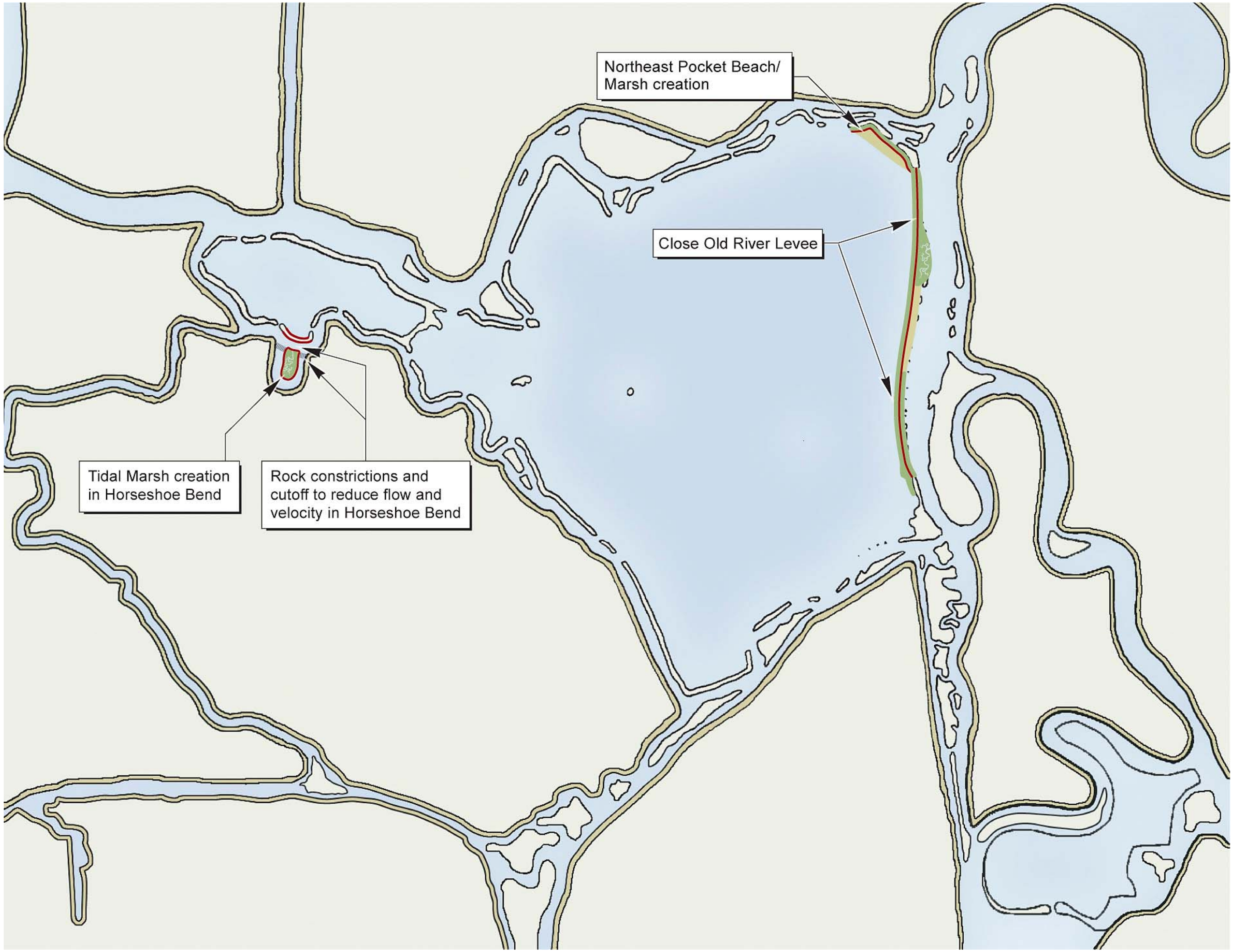
North Levee and Two Gates Alternative—Preliminary Pilot Project Components

EXHIBIT 5.3-3

0 1500 3000
FEET

NORTH

EDAW



Preliminary Pilot Project Components

East (Old River) Setback Levee Creation

Rock Constrictions in Piper Slough

Horseshoe Bend Cutoff and Tidal Marsh Creation

Northeast Pocket Beach/Marsh Creation

Legend

- Existing Levee
- Rock Dyke
- Rock Constrictions
- Tidal Marsh
- Beaches

Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

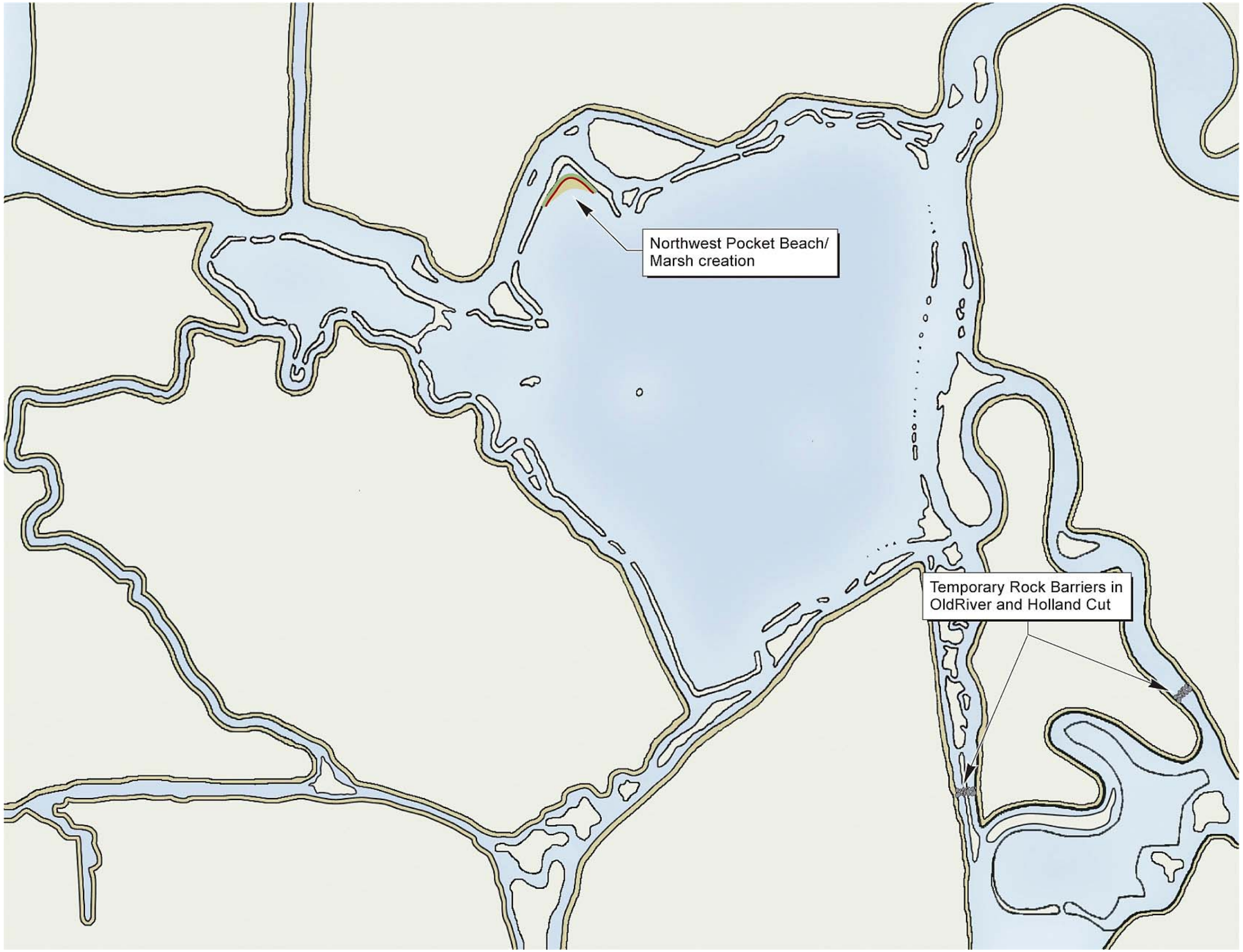
EXHIBIT 5.3-4

East Levee and Two Gates Alternative—Preliminary Pilot Project Components

0 1500 3000
FEET

NORTH

EDAW



Preliminary Pilot Project Components

2 Temporary Rock Barriers

Northwest Pocket Beach/Marsh Creation

Legend

Existing Levee

Rock Dyke

Temporary Rock Barriers

Tidal Marsh

Beaches

Source: EDAW 2005, NHI 2005, Moffat & Nichol 2005

Cox Alternative—Preliminary Pilot Project Components

EXHIBIT 5.3-5

0 1500 3000
FEET
NORTH

EDAW

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APPENDIX A

COMMENT LETTERS

Comments From California Bay-Delta Authority and Project Team Responses *

Flooded Island Feasibility Study Report Review Form
CALFED Bay-Delta Ecosystem Restoration Program
June 14, 2005

***DRAFT* Review Summary:**

Major points to address in Final Version of this report:

1. Clearly describe the objectives and expected outcomes of the study as written, which are different than the original study objectives, and document reasons for the changes in objectives

   <u>See Chapter 1 for additional language discussing changes to the original objectives.</u>

2. Clearly define "opportunities" and "constraints" and link directly back to the objectives.

   <u>See Chapter 2 for additional explanation of terms and summary table that illustrates how they link back to objectives.</u>

3. Clearly describe and justify how the "potential approaches" and "primary scenarios" were derived. Identify the criteria that were used to select the approaches and scenarios (and to dismiss others). The modeling to support the dismissal of Sherman Lake and Big Break as having effects on salinity **must** be documented. Expand on how criteria were used to complete the fatal flaw matrix. Point out if and how criteria or export/diversion locations were weighted in the analysis. Clearly identify the ecosystem restoration site selection criteria.

   <u>See Chapters 2 and 3 for additional explanation of terms, summary table, criteria, and preliminary modeling results/reasoning for dismissing Big Break and Sherman Island. Benefit-cost analysis in Chapter 4 has been revised to include weighting by diversion (volume). Chapter 3 provides additional explanation of ecosystem site selection criteria.</u>

4. Provide scientific citations for conclusive statements, or, if no or few citations for primary sources are available, qualify statements and acknowledge the uncertainty associated with them. **Explicitly** acknowledge assumptions, and identify where study outcomes are strongly influenced by assumptions.

   <u>Citations have been added throughout document.</u>

5. Be consistent in use of the term "water quality." Use more specific terms, e.g., "EC" or "salinity" rather than "water quality," when that is specifically what is meant. Define how "ecosystem water quality" is used in the report. Ensure that the terms "DOC" and "OC" are used accurately.

   <u>The terms "EC" and "Salinity" has been used where appropriate. The term "ecosystem water quality" could not be found. Clarification regarding the use of "DOC" and "OC" has been made.</u>

6. Clearly define residence time as used in this study and identify how it is different than the most common definition (see comments from reviewer #4 Scientific validity).

   <u>Definition of the term "residence time", as used in the report, has been provided in a discussion of residence time in Chapter 3.</u>

* Responses to comments are indicated as underlined text.

7. Remove or correct inaccurate statements about DOC and mercury. Clearly acknowledge the limitations of this study, **especially regarding DOC, mercury, and DO analyses**, and identify how those limitations will be addressed in the next study. (See especially comments from reviewers #4 and #8).

    The Administrative Draft document acknowledged the high level of uncertainty associated with DOC, mercury, and DO. This has been emphasized further in the final document (see Chapters 2, 3 and 4) and any speculation has been qualified. Many of the comments made by reviewer #8 do not accurately portray what was presented in the draft report. See specific responses below.

8. Improve recommendations for future work based on
    a. Identification of key limiting factors or uncertainties

        See Chapters 2 and 5.

    b. Identification of the limitations of the current analysis

        See throughout document.

    c. Testing of tools or field verification of their effectiveness at the appropriate scale

        See Chapters 2 and 5. Chapter 2 identifies monitoring and adaptive management as a potential approach.

    Identify future work necessary to inform determinations and development of a pilot study, and either identify clear criteria for selection of a pilot project and measurable objectives for a pilot project, or document how these criteria and objectives will be determined in the next study. (See more detail in comments from reviewers #1 and #4 Future work.)

        See Chapter 5.

9. Identify how future modeling efforts will address reviewers' water quality modeling comments, especially reviewers #4 and #8.

        See Chapter 5.

10. Identify how next steps will more thoroughly address beach stability, local residence time, Egeria and the invasive clam.

        See Chapter 5.

11. Incorporate specific comments of reviewers as much as possible.

        See response to specific comments below.

Individual Reviews:

Reviewer: Reviewer #1

Review:

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The objectives of the study (page 1-3) identify ecosystem values, water quality for water supply, and recreation as the focus of the study with some reference to flood control. For most studies the objectives would more explicitly point to an expected outcome. In this study, even though 'habitat diversification' is identified as the mechanisms of interest in objective 1, and marsh restoration is the focus on objective 2, the study really addresses the manipulation of tidal flows (rather than habitat diversification) as a means to alter water quality at various locations within the Delta. It seems that interests have changed since the inception of the effort, and this should be described and reflected in clear statements at the beginning which indicate the intent and expected outcome. Planning processes are frequently, almost preferably, iterative and the feasibility study would have more integrity and internal consistency if the objectives were reframed to focus on the things the study as written actually set out to do. It is also possible that some of the objectives as currently stated are in conflict with one another.

<u>The alternatives presented in Chapter 4 and pilot projects presented in Chapter 5 each include recommendations for water quality, ecosystem, and recreation related improvements. Where possible, these improvements were integrated within the general framework of "habitat diversity" (e.g., setback levees [water quality] with beaches [recreation] and marsh [ecosystem]) to achieve Objective 1.Clarification regarding project objectives have been added in Chapter 1. Tables are provided in Chapters 2 and 4 that link objectives to the alternatives.</u>

The opportunities and constraints assessment (it is not sufficiently quantitative or even structured to be considered an analysis) does not show clearly how it builds on the objectives, or how the component parts are linked. For instance, the list of 'conditions' identified on page 2-2 which provide the structure for the assessment are not founded in a technical discussion of Delta dynamics. The 'ecosystem' issues are really not issues but habitats or species. At this point in the document a conceptual model of how these 'conditions' interrelate within the flooded islands and their surrounding channels could help show why these have been identified.

<u>A discussion of Delta dynamics is provided in Chapter 1. A summary table that links Chapter 2 to objectives is provided at the end of Chapter 2. A conceptual model of the feasibility study is provided in Chapter 1.</u>

Within Chapter 2, opportunities, and constraints are identified with little definition of terms which allows for some confusion in the text. For instance, the issue regarding clam grazing on DOC is not presented clearly as an 'opportunity', and in many instances costs as assumed a priori to be a constraint (even when the purpose of most feasibility studies is actually to assess costs relative to the various benefits of action). This poor definition of terms and a failure in many cases to link the opportunities **directly** back to the objectives, is problematic. Similarly, it is not clear at all how the 'Potential Approaches' are derived or how they emerge, if at all, from the 'analysis' of the opportunities and constraints. Much more detail is required here and a justification for how these approaches were developed. In some instances, for example on 2.2-13 under DOC, the potential approaches are not actions at all, but lists of uncertainties. The section could be greatly improved by perhaps including sections on 'Critical Uncertainties' which are not the same as constraints, and applying a consistent approach to allocating issues into the categories.

<u>A summary table that links Chapter 2 to objectives is provided at the end of Chapter 2. The report acknowledges that there are conflicting conditions/issues and in certain cases opportunities may</u>

<u>also be constraints. Additionally, in some cases, the identification of opportunities and constraints can be highly uncertain (e.g., DOC, methyl mercury, and *Egeria*); in these cases the recommended potential approaches included monitoring and adaptive management, not additional uncertainties.</u>

The consideration of issues in the opportunities and constraints section is wide and the study does a good job at this point of identifying some of the issues that should be considered. In some cases the study stretches perhaps too far in considering the possible opportunities presented by the restoration potential. Lists of species that could benefit without a clear identification of the project features that would be necessary to produce the benefit doesn't inform the feasibility assessment well. The specific habitat requirements of the species (for example, those listed on page 2.3-2) must be identified for the project to take advantage of this 'opportunity'. Plans cannot be developed to address these needs or avoid the constraints unless cause-effect relationships are more clearly identified.

<u>Much of the information in the feasibility study is based more detailed information provided in the Baseline Report. See Baseline Report for additional details on all resource topics. We disagree that the possible opportunities for the restoration potential was overstated. Restoration associated with new setback levees or restoration of Little Franks Tract may provide benefits as discussed in the document. Restoration of new and preservation of existing tidal marsh habitat is a desired outcome of CALFED (and other) efforts. The opportunities as presented in the document were clearly identified as potential benefits and were by no means definitive.</u>

Without knowing the detail of the recovery plans for at-risk bat species, it also seems that the buildings and flood gates, fail to provide 'native habitat'. There is no need to stretch the potential benefits of this effort beyond those which may be supported by the habitats incorporated specifically in the design.

<u>Regarding constructing gates that may be suitable roosting sites for bats, it was not stated that the project would provide "native habitat" but rather "suitable habitat". This has been demonstrated by the noted species use of constructed features for roosting. A citation has been added in the document.</u>

However, despite this comprehensive approach some of the issues raised, such as MeHg and Corbicula, are not carried through in the rest of the study.

<u>Uncertainties identified for MeHg and *Corbicula* are presented in Chapter 2. Because of the uncertainties associated with these two issues, it was deemed appropriate to limit discussion regarding potential impacts and/or benefits associated with these issues for each alternative. Additional discussion is provided in the Baseline Report.</u>

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

Comments on many aspects of the approaches are provided in other sections (e.g., Alternatives Analysis). In general, the study is poorly supported by scientific citations and the validity of many of the statements made cannot be assessed. Some sections include abundant references, e.g., the Hg section, but in most others statements are not supported by studies. In many cases citations are to other consultant reports with few primary sources listed. Personal communication from experts is reasonable, but thresholds of elevation for vegetative growth (e.g., the depth tolerance of Egeria, or the growth limit for Tules) which substantially impact the feasibility outcomes in term of costs of fill must be supported by data or studies. There are so many unsupported assumptions in the study that could undermine the validity of the conclusions. It is essential that these assumptions are explicitly acknowledged and where they have major implications for the proposed features, the sensitivity of the study outcome to these assumptions must be assessed.

<u>Scientific citations have been added to many statements throughout the document. Also, please see the Baseline Report for additional cited information. Regarding use of personal</u>

communications for Egeria, we relied heavily on Lars Anderson of USDA who is recognized for his considerable knowledge of this species.

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

Chapter 3 suggests that there will be a logical process used to formulate, evaluate and compare alternatives. This section also refers to another document – the 'Conceptual Alternatives Report' which was not provided as part of this review. It is possible that some of the fundamental questions on this section may be addressed in the report.

Early in Chapter 3 there is a major departure from the Objectives of the study. Rather than habitat diversification to address water quality, ecosystem restoration and recreation, the approach for water quality is the alteration of tidal hydrodynamics. This must be justified and explained.

Habitat diversification to address water quality was 1 of the 4 objectives. See Chapter 2 summary table for a complete linkage of objectives, issues, opportunities, constraints, and potential approaches. Chapter 3 has been reorganized to better present the selection of preliminary alternatives in relation to objectives. Also, see "Relationship to Objectives" for each of the alternatives in Chapter 4.

The 'Primary Scenarios' in table 3.1 are essentially a list of approaches that could be used to meet the project objectives. It is not clear how they were derived or why they are considered 'primary. Similarly, the 'most promising' tools are identified in Table 3.1 with no justification for why these are promising. No criteria are presented for the selection of the tools or the scenarios. Such criteria might include their successful use elsewhere in the Delta, in other tidal systems, proven by modeling but not in practice, etc.

The "primary scenarios" and "tools" were developed from the "potential approaches" outlined in Chapter 2, see summary table.

It is essential at this and other points in the study to show a clear line of reasoning that links the objectives to the opportunities to the approaches/strategies to the tools.

See Chapter 2 summary table.

The description of the tools and how they are conceived needs to be amplified. For instance, the habitat levees are apparently expected to withstand wind wave erosion. However the conceptual designs show central structures (either rock or wall) with beach and marsh in either side. It is not clear here how the beach or the marsh survive if there is indeed major exposure to wind waves, and why some type of offshore breakwater system around a central habitat/beach is not preferred to a central structure surrounded by unconsolidated material. Another example is the dismissal of certain types of proven avian habitat restoration as being too expensive while fill for tidal marshes (or even some kind of reverse liposuction using slurries) is kept on the table. This inconsistent, or at least poorly justified, selection of some tools over another does not serve the study well. Rather, clear criteria should be used and consistently applied to identify the preferred tools.

See Chapter 3 for additional explanation of criteria. Additional information is also provided in this chapter regarding sustainability and design of setback levees.

Similarly, more detail is needed to show how the site selection for the applications of tools, essentially the development of the alternatives, was determined. Sherman Lake and Big Break are dismissed as having no effect of water quality. The modeling to support this must be shown in the study. Also – if the objectives on page 1-3 were those really guiding the study these may not be dismissed if habitat diversification there could meet some of the eco and recreation objectives. Further exploration of what else could be considered at these sites may have identified alternatives with water quality benefits. For instance, if Sherman Lake provides a conduit for Sacramento water to enter the San Joaquin could that transfer of water not be enhanced by increasing the efficiency of water movement through the Lake, or Mulberry Slough, or associated channels, to provide WQ benefits? The study states that changes could only decrease the flow – this means too small a range of 'changes' have been considered. This project seems to focus too early on manipulation of salt rather than encompassing the mixing process and how it can be changed in a broader sense.

> <u>This is thoroughly discussed in Chapter 3. Also see the Modeling Calibration Report and the Conceptual Alternative Report.</u>

The criteria used to identify the nine alternatives must be clearly stated.

The Fatal Flaw matrix is a good tool for preliminary screening of alternatives. However, the criteria used to complete the matrix must be clearer. Examples include:

- How long must EC be reduced by how much? The model may indicate decreases that are of little significance to water supply. If EC is already low enough, getting it lower shouldn't always be a benefit.
- What exactly is the residence time criteria based on? The text indicates studies that show 20 days may not be a problem, but smaller times seems to be assessed negatively in the matrices.
- What makes any of the criteria fall into the FATAL category?
- How is uncertainty about the outcome in the matrix incorporated? The implication of the poor model calibration at SWP must be more fully explored here.
- Why cannot a change in EC be considered a Fatal Flaw?

The Fatal Flaw matrix approach should be expanded to include all of the possible outcomes of the alternatives. Screening should then be conducted on a full assessment of the impacts and benefits of the alternatives. At present, screening is conducted on WQ in isolation of the other factors.

> <u>Reductions in EC were evaluated and compared from a relative standpoint without thresholds. Increased residence time was generally assessed negatively in the screening. See Chapter 3 for explanation of when criteria would fall into the "Fatal" category. The matrices are on evaluation device used in the study, see Chapter 3 for addressing uncertainty in the matrices. A change in EC is not considered a fatal flaw because optimization and/or refinement may result in significant change.</u>

The ecosystem restoration site selection criteria are very poorly defined. The categories used to rank options in Table 3.4-1 must be clearly identified and justified. What make a patch large medium or small – in relation to what? How is topographic diversity categorized? Perhaps most importantly how are all the criteria in the Table used to assess a final rank?

> <u>See Chapter 3 for additional explanation. Also, see the Conceptual Alternative Report.</u>

For the selection of locations for the habitat levees, the same justification must be provided. Here it seems that the criteria are binary, all are weighted equally and ranking is based on how many criteria are met. This approach must be explained and justified – especially given the different approach used to tidal marsh restoration.

> <u>See Chapter 3 for additional explanation.</u>

The selection of 'representative' alternatives from groups for further analysis based on a crude categorization of the tools used to achieve WQ benefits, seems to mask some important differences among the alternatives. Two of the nine, No FT and East Side open, include no tidal control structures. Given that one of the feasibility criteria to is be sustainability, the concept of including a detailed evaluation of at least one alternative that requires less O&M, future consumption of power, etc based on a non-operational approach to achieving the objectives would seem reasonable. East Side open has no obvious fatal flaws given that no case is made for a residence time of 12 days having fatal effects. The approach for the selection of the final alternatives does not appear to be based on any objective, quantitative metrics (or even ranks) related to the either the objectives or the stated evaluation criteria (see discussion of sustainability above). Why do all of the preferred alternatives include marsh creation at LFT? The evaluation provided here does not adequately support this as the only way to achieve marsh creation.

> No FT and East Side Open both had fatal flaws (fill material required and unacceptable for recreationists and Bethel Island residents, and blocked access to/from Bethel Island, respectively). The relatively confined nature of LFT gave it an advantage over several other locations. Also, see Chapter 3 for additional explanations.

The calculation of the BCI adds nothing to the analysis presented. The comparison of a percentage with a dollar value can be done directly without the need to multiply one by 100, and divide the other by 1,000,000. The exercise does not scale the values by a reference value – it merely makes the numbers fall within a certain range. In addition, the idea of averaging % change across four WQ locations (with different amounts of water extracted at each) as a measure of WQ benefit seems too simplistic.

> The BCI calculation was done solely to make reviewing the numbers easier on the reader. The BCI analysis has been revised to be weighted.

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

I cannot comment on the specifics of the WQ benefits evaluated or their geographic range. However, little explanation or justification is given for the time period and scale over which the analysis is conducted. The fact that only one of the structures is modeled with a variable operational regime clearly makes comparison among the WQ benefits of the alternatives inappropriate. Given that the team identify this as a problem, it seems curious that the study was completed in this manner. By acknowledging these limitations how can the study team justify using as quantitative BCI to compare alternatives where the calculations of % change are based on incomparable data?

> See Chapter 3 regarding time period used in the modeling. The study acknowledged limitations in the modeling and recommends that the refinement and optimization of each alternative be conducted.

5. **Water Quality Modeling.** For the water quality modeling component:
   a. Is the selected model appropriate for the level of analysis?
   b. Is the selected model appropriately calibrated?
   c. Are the modeling assumptions clearly identified, and are they appropriate?
   d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
   e. According to the study has the selected model been peer reviewed?

Beyond this reviewers expertise except where some modeling issues are covered in other comments.

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

Given the limitations of the analysis, inadequate application of criteria, and the apparent pre-selection of tools to be used to address the WQ objectives, the study does not provide an appropriate basis for recommending future work. The purpose of the proposed Pilot project is unclear. The study should point to future work based on:

- Identification of key limiting factors or uncertainties, and aspects of a pilot project which could be used to reduce these limits/challenges.

- Identification of the limitations of the current analysis. Presently the study points to the need for fisheries data without stating how the study could be improved by this.
- Testing of tools or field verification of their effectiveness at as small scale where appropriate (e.g., will beaches erode? will dendritic channels form? what is the recreational response to barriers across heavily traveled channels?).

Key uncertainties and potential approaches for dealing with them were identified in Chapter 2. See Chapter 5 for information on how the study would be improved and for an explanation regarding one of the purposes of the pilot projects (e.g., testing and field verification).

The study does not identify clear criteria for the selection of a pilot project or measurable objectives for a pilot project.

Development of criteria and measurable objectives for pilot projects is recommended as a next step.

Prior to a pilot study a more objective evaluation of alternatives employing a wider range of approaches should be evaluated. The preferred group alternatives should be based on their representation of the approaches or their cost-effectiveness. Cost could be measured both in $ and in the amount of sediment required given that both are a limiting resource in the Delta. Each alternative should be seen as a series of increments (e.g., is the effect achieved in part by implementing only some of the tool, so many miles of levees, or so many acres of fill) and the costs in $$ and sediment terms compared to the outcomes relative to WQ, eco and recreational benefits. Pilot projects could then be used to begin implementation of the most effective increments, or those efficient components associated with great uncertainty.

Recommendations for additional analysis, evaluation, and refinement of alternative and pilot projects were provided in the Administrative Draft. Total and unit costs were provided for importation of fill material (Chapter 4).

7. **Additional Comments**.

I found several inconsistencies, repetitions, and misplaced tables within the document. It should be structured to be more concise in the text, and to show how the bulk of the document emerges from the study objectives.

The problem statement and methodology sections (Chapter 1) were expanded significantly since production of the Administrative Draft. See Chapter 2 summary table and see “Relationship to Objectives” for each of the alternatives in Chapter 4.

Reviewer: #2

Review:

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

I have been asked to review the Fisheries portion of this document, so all of my replies will focus on Fisheries and other relevant ecosystem processes. Overall, I feel like the authors did a good job in integrating the various components and explaining the progression from initial goals through preliminary alternatives and final recommendations. The definitions in the various sections are adequate, especially when dealing with more complex issues such as Mercury. The tables and figures throughout the document are especially helpful in grounding the reader with the wordings in the text and models.

One aspect I thought could be better explained in the Introduction is why the specific focus on Lower Sherman Lake, Big Break, and Franks Tract; I'm thinking specifically on the absence of Mildred Island. I assume this is because of the suitable location of the other three sites in regard to salinity trapping, as well as Mildred Island's location on the Middle River not being on as a direct path to the pumps. It would still be nice to mention it early in the report as a prominent flooded island, especially since later in the document it mentions that there is a lack of *Corbicula fluminea* at Mildred Island and that it would serve as a good study area.

See Chapters 1 and 3 for explanation of why the study areas were chosen and mention of Mildred Island (also noted in Chapter 2 regarding studying the difference associated with *Corbicula* presence).

Another discussion I felt lacking was a brief introduction on other Submerged Aquatic Vegetation (SAV) in the Delta besides *Egeria densa*, both non-indigenous and native. Although *Egeria* is definitely the most prominent and troublesome, there are some other species whose presence should be noted, so that the reader doesn't think that all SAV is bad. Specifically I'm thinking of the non-indigenous Parrot's Feather *Myriophyllum aquaticum*, and the natives Water Primrose *Ludwigia peploides* and Coontail *Ceratophyllum demersum*, and various types of Pondweed *Potamogeton* spp. amongst others. I think there is also an important role of Floating Aquatic Vegetation (FAV), notably the non-indigenous Water Hyacinth (*Eichhornia crassipes*) which has had very large abundances in the past and is currently controlled by the California Department of Boating and Waterways, and the native Pennywort *Hydrocotyle umbellata*.

Paragraphs on native SAV as well as FAV have been added in Chapter 2. A paragraph in the Opportunities section has also been added. Also, see Baseline Report for additional discussion.

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

I think the scientific validity of this report could be much improved by including more references in the scientific literature. This would allow readers to access other publications when they feel they need more information to understand what is being discussed. This would further give credence to the authors that they have done their homework and have a thorough understanding of the various topics. Although there is no need for a comprehensive listing of all relevant reports, a few key references would be beneficial, especially in regards to fish communities and SAV/FAV:

Additional citations have been added throughout document. Also see Baseline Report for additional information.

Brown, L. R. 2003. Will tidal wetland restoration enhance populations of native fishes? *in* L. R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1, Article 2.
http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2.
…especially the conceptual models on fish habitat use with and without SAV.

Grimaldo, L.F., W.Kimmerer, A.R. Stewart. 2004. Diet and carbon sources supporting fishes from open-water, edge and SAV habitats in restored freshwater wetlands of the San Francisco Estuary. Master thesis, San Francisco State University, San Francisco,
California.

Toft, J. D., C. A. Simenstad, J. R. Cordell, and L. F. Grimaldo. 2003. The effects of introduced water hyacinth on habitat structure, invertebrate assemblages, and fish diets. Estuaries 26:746-758.

I think the detail on the fish species that utilize flooded islands and could be affected is a bit light in detail. This may be intended, as it is stated that "A more detailed discussion of the specific fish species that may be affected by modifications to the flooded islands can be found in Section 4.7 of the Flooded Islands Feasibility Study Baseline Report." However, not having this other report, the description comes across as a bit vague, since this is a complex issue.

In the WEST FALSE RIVER GATE ALTERNATIVE (P. 4-8) it is stated that "San Joaquin River fall-run chinook salmon migrate through the Delta in the fall months, but operation of the barrier would not impede their migration because the barrier would be open at least half the time." This should be changed to what is stated in later discussions of striped bass and salmon, which states that operation of the barrier could be disruptive. Stating that the barrier will "not impede" is misleading, at the very least it should say "minimally" impede, as it has the potential to be disruptive if it blocks migration half the time.

It should be mentioned that the effect of the various barriers on *Egeria* growth could be similar for Water Hyacinth, by blocking flow this could also block in rafts of Hyacinth that wouldn't be flushed away and therefore stimulate more growth.

<u>See Baseline Report and additional detail provided in Chapters 2 and 3. See Chapter 4 for additional mention of water hyacinth.</u>

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

Yes, I think the development of the alternatives is well explained, and flows nicely from the preliminary alternatives into the preferred alternatives and final recommendations. Even though my focus was on evaluating the Fisheries component, I felt that all of the criteria were well represented in the decision process.

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

Water quality is out of my area of expertise, since my review is focused on Fisheries aspects. However, I found the water quality discussions to be very well organized. Evaluating it from my objective point of view, I found that I understood the various components and the train of thought of the authors.

5. **Water Quality Modeling.** For the water quality modeling component:
   a. Is the selected model appropriate for the level of analysis?
   b. Is the selected model appropriately calibrated?
   c. Are the modeling assumptions clearly identified, and are they appropriate?
   d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
   e. According to the study has the selected model been peer reviewed?

Again, this is out of my area of Fisheries expertise, but from an objective point of view I found the modeling component to be a useful technique for organizing and conveying the pros and cons of the various alternatives.

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

I would like to see more analysis of the effects of opening and closing the tide gates on flood/ebb tides, and during various seasons. It is mentioned in the report that additional modeling is necessary for this, which I agree is vital to the development of the project. It should not be ignored the effect that the blocking and low flows could have on fish as well as growth of *Egeria* and Water Hyacinth. The information I have is that DBW sprays for Hyacinth from July 1 to Oct 15. If barriers are closed before this, low flows may increase growth/limit flux of SAV/FAV.

<u>Water hyacinth has been added in Chapter 4.</u>

It is mentioned in the report that "Fisheries Field Data Collection and Investigations (with multiyear monitoring)" is recommended for refinement and optimization of alternatives. I think this is a necessary component for the success of the project, since there are so many unknowns with respect to native fish species. There are many questions as to the effects of the alternatives on *Egeria* and corresponding fish communities. I think the report would benefit greatly by incorporating a field-based research and monitoring program that can quantify such relationships throughout the development, implementation, and operation of the project.

7. **Additional Comments**.

Overall I think this is a comprehensive and well-organized report, and look forward to the continuing development of final recommendations and success of the project.

Reviewer: #3

Review:

1) **Comprehensiveness.** This study is essentially a scoping exercise in which a number of possible alternatives ("concepts") to meet water quality and other measures are explored. As the title implies, it assesses how a combination of engineering, ecosystem restoration and levee modifications to (three) flooded Delta islands will affect water quality at the export/diversion points in the south Delta, as well as effects on fish and other species of special interest and recreational values. In my opinion, the report is comprehensive in that it includes discussions of effects across the relevant impact categories of interest to CBDA, stakeholders and other interested parties. The report assesses such impacts for a broad set of alternative strategies and options. Given the complexities of the issues involved here, the report by necessity does treat superficially some of the nuances and intricacies which might be associated with the alternatives. However, this is a **feasibility** study, and the authors do a credible job of 1) explaining their criteria for evaluating likely effects, 2) presenting results in an easily accessible matrix of outcomes and costs and 3) noting what is missing or needs to be done in followup studies. The cost estimates used here for each alternative appear to be based on standard engineering accounting methods, and reflect costs for similar structures in the region. The costs are also conservative, in the sense that they include large upward adjustments for "contingencies" and other non-structural or non-project costs.
2) **Scientific Validity.** The processes used in the study appear to be common techniques for conducting a scoping exercise of this type. Specifically, the problem and empirical setting are identified, the list of policy options are enumerated and defined, and the effects of these on given state variables (e.g; water quality) are discussed. This is a feasibility study, it is not an attempt to perform original research. Instead, it uses common assumptions, insights from experts, and some modeling results from a water quality model to develop likely outcomes and costs. In my opinion, given the context of the study, the exercise is "scientifically valid".
3) **Alternatives Development and Analysis.** As noted above, the methods used here appear to be appropriate for the objectives of this study. I am not capable of judging the validity of all aspects of the conditions and assumptions (engineering and otherwise) embedded in the various analyses performed here but the report is transparent in terms of procedures, including strengths and weaknesses. I found the presentation of results to be easy to follow and the use of the matrix and associated fatal flaw analysis to be helpful. The validity of the findings (e.g. changes in EC at various points in the Delta) is a function of the water quality model, but to the extent that any model limitations are consistent across each alternative, one expects that the relative changes in basic water quality measures assigned to each option will be unbiased.
4) **Water Quality.** The primary measure discussed in the results is water quality in terms of EC at export or diversion points. This is not my area of expertise but I assume that such a variable is an acceptable proxy for drinking water quality. The report also discusses other water quality measures, such as DOC, which I assume also affects drinking water quality. The benefits of the alternatives are evaluated using an index number approach, where each alternative is rated in terms of changes in physical water quality (here EC). One possible extension of this analysis would be to translate these physical measures into some economic measure of benefits (say, reduced water treatment costs) associated with each water quality improvement. Also, as the authors note, there is no quantification (physical or economic) of non-market benefits associated with recreational values, endangered species or ecosystem services. This should be pursued to get a fuller sense of the consequences of the alternatives as the list of feasible options is explored in subsequent studies.

   <u>This suggestion will be considered for future phases/studies.</u>

5) **Water Quality Modeling.** I am not a hydrologist and can not comment on the validity of the model(s). However, as noted above, the model results are the basic output of this exercise and are used to determine which of the options pass the feasibility tests imposed here. Thus, the model(s) need scrutiny. I assume these are probabilistic models, so some discussion of the confidence intervals and uncertainties is warranted. I am not aware of whether these have been subjected to peer review.

However, I do note that much of the material used in this report is drawn from other reports, in which more detail is available.

> <u>The Calibration Report provides documentation on the formulation and performance of the hydrodynamic and water quality model utilized for this study. The model is not probabilistic. The model calibration report provides a significant representation of the accuracy of the model. However, during the pre-feasibility phase of this project, no attempt was made to provide formal uncertainty estimates for the predictions of salinity improvements at the export locations. Based on the model calibration, uncertainties are expected to be on the order of 10 to 15%, however, the next phase of the project should include more formal analysis of both model sensitivity and uncertainty.</u>

6) **Future Work.** The study does propose the next steps in this process. As I understand it, the report will go before the CBDA and decisions will be made regarding which, if any, of these options gets pursued. The follow-up studies will need to address the options in more detail; the report contains a useful list of shortcomings of the preliminary analyses, which are candidate items for inclusion in followup studies. I was pleased to see the recommendation to consider sea level rise in the next stage of studies. I would also suggest that the study consider effects of levee stability related to earthquakes and flooding (see comment below).

> <u>See Chapter 2 regarding potential opportunities under flooding, earthquake, and levee failure scenarios.</u>

Final Comment: This report is coming out at a time of increasing interest in levee stability and the role of the Delta islands in meeting CBDA goals. As you may be aware, a recent report by Mount and Twiss of the ISB, building on a DWR report by Torres et al., explores the probability of multiple levee failures due to earthquakes and flooding. While the Mount and Twiss report looks at the entire levee system, it has implications for the more focused effort evaluated in this study, in that levee failures elsewhere are likely to affect the outcomes of these more localized Delta measures. Also, as you are no doubt aware, DWR is beginning a two year Delta Risk Management Study (DRMS) to understand the role and consequences of the levees (and their possible failure) on the performance of CALFED operations. This issue of levee integrity and the Delta was a topic of considerable attention at the ISB meeting last month (May 10-11). Speaking only for myself, I believe the Delta levee situation is a major economic and policy issue that needs attention. Thus, I am pleased to see these various studies and analyses underway to address the long term challenges of dealing with the levees and the Delta.

Reviewer: #4

Review:

My background is in hydrodynamics and hydrodynamic and water quality modeling. Since, I do not have a broad enough background to answer all questions asked on this review form, I have focused my review on hydrodynamics and modeling.

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

Several desired outcomes are identified clearly. Several relevant issues are discussed in varying levels of detail, but I do not know the "full range" of relevant issues. More discussion regarding water quality analyses is provided in the response to question 4.

The most detailed analyses presented in the report are salinity analyses. The scope of the salinity analyses is probably appropriate for a feasibility analysis but is limited in several ways

- Only direct and immediate effects of alternatives are evaluated. Long-term effects of the alternatives are not considered in the salinity analysis.
    - o All analysis was done with existing morphology. However, the proposed construction will alter circulation patters and sediment transport and, therefore, lead to geomorphic change. The longer-term effect of the proposed alternatives, including resulting geomorphic change, is not evaluated.
    - o Similarly, sea level rise and climate change (change in timing and magnitude of flow events) are not considered in the simulations.
    - o Additional restoration or levee failures could change the effects of the alternatives.
    - o Scenarios for spread of Egeria are not considered in the salinity modeling
- Operation of proposed gates is not optimized.
- Beach stability is not discussed in the report. Is there an expectation that the beaches will be stable? If not, is the maintenance of the beaches included in the estimated budgets?

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

The numerical modeling approach used in the study may be adequate to address salinity issues. The RMA2 model has a long history of application in the Delta and was calibrated against a large set of data. Several assumptions and limitations of the model are outlined but model uncertainty is not discussed in adequate detail (see comments under question 5).

A substantial shortcoming of the report is limited reference of scientific literature and the relatively large number of "personal communications" cited. Whenever possible, statements of relevant knowledge or observations should be accompanied with citations of peer-reviewed literature. Much relevant literature has recently been synthesized by Kimmerer (2005) in San Francisco Estuary and Watershed Science.

<u>Additional citations have been added throughout the document.</u>

Several assertions are made in the report without explanation or citation of relevant literature. For example "large scale DO changes in Franks Tract would be unlikely" is stated without explanation.

<u>These types of assertions have generally been qualified throughout the document.</u>

The algae production model discussed on page 3-50 appears to be quite limited and may be inaccurate, particularly because it does not account for grazing.

The model does account for grazing, see additional language provided in Chapter 3.

The discussion of the residence time analysis is limited. Given that there are multiple definitions of residence time that are used in practice, both the definition and approach should be carefully documented. I found a definition in the Alternatives Modeling Report Draft by RMA. This definition should also be included in the Feasibility Study Report by EDAW. The definition by RMA is substantially different than the most common definition (e.g., Dronkers and Zimmerman, 1982) and may lead to smaller estimates of residence time than residence time according to the most common definition/approach.

A complete definition of residence time, as used in the report, is provided in Chapter 3.

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating, and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

The methods for evaluating and comparing preliminary alternatives were quite clearly documented. Several relevant evaluation criteria were selected though many more evaluation criteria could be taken into consideration. For example, I think that stronger consideration should be given to alternatives that provide operational flexibility, and can be implemented as pilot projects at reasonable expense. Similarly, options with less scientific uncertainty in water quality and other effects should be given more weight.

This suggestion will be considered in future phases of the study.

A key limitation of the comparison of alternatives was the lack of optimization of gate operation in most alternatives.

Agreed, this limitation was noted in the report and will be addressed in future phases of the study.

The benefit analysis was not clear but apparently weighted each export/diversion location equally. This does not seem appropriate.

The Final Report includes weighted benefit-cost analysis.

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

I can not judge the adequacy or appropriateness of the evaluation overall but it seemed uneven in level of detail of the water quality analyses. Relative to the detailed salinity modeling that was conducted the DO and DOC analyses seem to be based largely on professional opinion with little quantitative analysis. Given the apparent lack of quantitative analysis, some statements imply a surprising degree of confidence (e.g., “Although residence times would increase..., it would not be to a level to cause noxious algal blooms...”)

<u>Some statements have been qualified throughout the document. Additional analysis of DOC is recommended for future phases.</u>

The discussion of mercury was also much less substantial than discussion of EC/salinity. The concept of the “reactive mercury pool” was not explained in adequate detail and expected effects of different alternatives on the “reactive mercury pool” are not discussed.

<u>Additional analysis of mercury is recommended for future phases. Also, see the Baseline Report for additional information on mercury.</u>

As stated previously in my comments, the time period/scale of analysis is implicitly the period directly following implementation of an alternative. Potential longer term changes resulting from the implementation of alternatives, such as geomorphic change, or independent of the project, such as sea level rise, are not considered in the analysis. This is probably appropriate for a feasibility analysis, but, given the great importance and expense of the proposed alternatives, further analysis would be useful in an EIR-EIS. The rationale for the chosen simulation period appears to be primarily that it is the model calibration period and that it is during summer conditions when water quality concerns are present.

<u>Agreed, this suggestion will be considered in future phase of the study and would be addressed in an EIR/EIS.</u>

Only a portion of the future modeling needs is clearly identified. The report does mention that a broader range of hydrologic conditions may be considered in later phases and that the simulations should optimize gate operation. Additional modeling needs are described in my comments under question 6.

<u>Additional clarity has been provided in Chapter 5.</u>

5. **Water Quality Modeling.** For the water quality modeling component:
    a. Is the selected model appropriate for the level of analysis?
    b. Is the selected model appropriately calibrated?
    c. Are the modeling assumptions clearly identified, and are they appropriate?
    d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
    e. According to the study has the selected model been peer reviewed?

The numerical modeling approach used to address salinity and flood stage issues is appropriate but limited. The assumptions and uncertainties associated with the model are not adequately discussed. Before construction of pilot projects a substantial uncertainty/sensitivity analysis should be performed to better understand the uncertainty associated with the model’s predictions.

<u>Agreed, this has been included as a recommendation in Chapter 5.</u>

Because the validity of the modeling approach depends strongly on the degree of model calibration, I reviewed the RMA Delta Model Calibration Draft. Clearly a large amount of work has gone into model development for this complex system and the degree of comparison to stage, flow and salinity observations is generally high. However, discussion regarding model assumptions, limitations, and uncertainty is limited. I have the following substantial comments on the model calibration document:

- The model calibration report suggests that the model accurately represents stage, flow and salinity throughout most of the Delta during summer conditions. However, it should give greater emphasis to the prediction of salinity at export/diversion facilities. For example, a table could compare the predicted monthly averaged EC (used as the metric of salinity reductions) to the observed monthly averaged EC for each month during the simulation.

- The document should discuss limitations of depth-averaged modeling, which may be substantial in Suisun Bay and significant in the western Delta. Not representing vertical gradients in salinity may limit the model's predictive ability. For existing conditions, "three-dimensional processes" can be parameterized to some extent by dispersion coefficients. Table 3-1 suggested that various tuning coefficients were tuned in multiple regions to improve the calibration. However, for project conditions or flow conditions different than the conditions present during model calibration, mixing parameters may no longer adequately represent "three-dimensional processes" because the location, strength, and tidal phasing of stratification will be different under these different conditions.
- Potential errors introduced in the salinity boundary condition should be discussed in detail. On Page 4-1, the document states that "the average of surface and bottom EC was used." This suggests at least two substantial errors:
    - o The average salinity of top and bottom observations does not accurately represent depth-averaged salinity.
    - o Depth-averaged salinity at the salinity station does not accurately represent cross-sectional average salinity.
- The method of handling wetting and drying should be discussed in more detail. It is not clear from the discussion if the method conserves water volume or if velocities are estimated realistically in shallow regions.
- On Figure 4-6, Mildred Island is not shown as a flooded island. Is it treated as a flooded island in the RMA model? If not, this assumption seems inappropriate and is not discussed in the text. If it is treated as a flooded island, all relevant figures should reflect this fact.
- Page 7-1 states that "EC is treated as a conservative constituent for model simulation." However, EC is not conservative; therefore this assumption will lead to some error. Is this error significant? Salinity is conservative, why is it not used in the model?
- Page 2-1 states that "the RMA2 model is capable of representing the influence of a baroclinic distribution..." It should be noted that RMA2 can only represent depth-averaged baroclinic pressure gradients. Because it is a depth-averaged model, it can not account for the vertical variability in baroclinic pressure gradients that leads to gravitational circulation. This should be noted for clarity.
- The representation of vegetation in the simulations is reflected in the Manning's n coefficients in Table 3-1, but not discussed in any detail.
- It is not correct to refer to the Smagorinsky sub-grid scale mixing approach as a "turbulence closure" (e.g., page 3-6 and 10-6). This approach estimates sub-grid scale mixing based on resolved (grid scale) velocity gradients. Because the resolved velocities are Reynolds-averaged velocities (not turbulent velocities), the sub-grid scale mixing estimated by the Smagorinsky approach represents mixing due to small scale Reynolds-averaged velocities. The resulting mixing coefficients are generally larger than turbulent mixing coefficients which represent the effects of turbulent time and spatial scale motions.

<u>See Calibration Report and Alternative Modeling Report (RMA 2005). A table can be added to the calibration report comparing predicted monthly averaged EC with Observed Monthly Averaged EC. The model uses a depth-averaged approximation in the western Delta and Suisun Bay where significant vertical gradients in salinity are often present. Vertical gradients in salinity may lead to three dimensional circulation patterns that will not be represented by a two-dimensional depth-averaged model. Instead, the three dimensional processes are approximated by two-dimensional mixing parameters. The calibration results show that the model was able to very accurately transport salinity from the tidal boundary at Martinez, through Suisun Bay, to Jersey Point and False River for the 2002 period simulated. In other modeling work using the full RMA Bay Delta model with the salinity boundary applied at the Golden Gate, the two-dimensional representation has been shown work well during most conditions. The approximation has the most difficulty during the transient recovery of salinity following a large net delta outflow. In this case the model salinity recovers more slowly than the real system. Generally the model catches up to the observed salinity within one to two weeks</u>

following a large storm event. There is some concern that calibrated mixing coefficients would not be appropriate if the system configuration was changed significantly. Modeling of the Jones Tract levee failure has shown that the model performs adequately given a large change in tidal prism. In the modeling of the Feasibility Study alternatives, there were no changes proposed that would strongly affect the flows through Suisun Bay, and, therefore, the calibration of mixing coefficients will probably not be affected. This issue could be explored further during a future phase of the project.

The model network used for the alternative analysis approximated Mildred Island as off-channel storage of the one-dimensional elements surrounding the island. A test simulation was performed with Mildred Island represented with two-dimensional depth – averaged elements, but there was no significant improvement in accuracy of the model with regard to overall flows or salinity transport in the Delta.

Additional discussion of EC will be added to the calibration report.

Additional discussion of the approximation of the baroclinic pressure gradient and Smagorinski method will be added to the calibration report.

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

The report does clearly identify pilot projects. However, it does not discuss monitoring the effects of pilot projects or how the success of pilot projects will be evaluated.

Developing monitoring and success criteria have been identified as a recommendation for future phases.

Additional modeling would reduce uncertainties and improve confidence in the modeling approach

- Sensitivity analyses could provide insight to model uncertainty.
- Applying the model to a wet and/or an extremely dry (drought) period, without altering any model parameters, would provide insight to the predictive ability of the model. If the model does not predict salinity accurately during a wet period, this suggests that model parameters apply only for the conditions of the model calibration period and would decrease confidence in the model's ability to predict project conditions.
- Supplemental application of a three-dimensional model, perhaps over a smaller model domain, would provide insight to the importance of salinity and temperature stratification. Such a small scale study of Mildred Island is in progress by Seungjin Beuk of UC Berkeley. Three-dimensional simulations will be increasingly important for many likely future scenarios, including sea level rise and levee failure scenarios, in which the salinity and stratification are likely to intrude further into the Delta.
- The RMA2 model, in conjunction with a three-dimensional model, should be applied to various future scenarios that include geomorphic change scenarios, sea level rise scenarios, climate change scenarios and restoration/levee failure scenarios.

The reviewer makes several clear suggestions for future work which should be considered if time and funding allow.

7. **Additional Comments**.

Editorial Comment:

- Redundant terminology is used repeatedly in parts of the report. For example:
    - "Stage elevation" should be changed to "stage"
    - "Salinity concentration" should be changed to "salinity"
    - Most instances of "salt content" should be changed to "salinity"

- “Erosion caused by scouring” should be changed to “scouring”

Suggested changes have been made throughout the document.

Reviewer: #5

Review:

1. **Comprehensiveness**.

Overall the report does an excellent job in stating the goals and objectives and then identifying the methods in achieving those goals. It is not clear why the report makes no distinction between the water quality, and volume, requirements of drinking water versus agricultural irrigation water. While weighting the difference drinking water and irrigation water would be subjective, it would present a point of view that could then be debated. As it is left in the report, it leaves the reader with complete autonomy in making his own judgment. The report identifies the rationalization of the other goals well enough to support future debate by stakeholders. The report will lack a little clarity for some readers in its mixed use of S.I. and U.S. Customary units. On page 4-45 the report refers to having performed the analysis for the year 2000 while earlier stating that the modeling was performed for the year 2002. There is no clear reference provided for the report's identification of riparian, tidal marsh, and riparian elevations of <-1-ft, -1 to +4-ft, and >+4-ft, respectively. I am not aware that there is a general agreement on these values and a clarification would be helpful. The same clarification would be helpful on the report's identification of shallow water habitat as being below 3-meters – one of the report's uses of S.I. units.

<u>The benefit-cost analysis has been revised to be weighted for each diversion point. The use of units has been made consistent. Modeling was performed for the year 2002, this typographical error has been corrected throughout the report. Citations have been provided for habitat elevations. All measurements have been changed to Imperial for consistency throughout the document.</u>

I might suggest further clarification of the following passages:

Page 2.3-11 – what are planktonic fish eggs and larvae?

<u>This statement has been clarified in the final report.</u>

Page 4-22 – three gates would be operated in tandem – while the meaning is clear, most would argue that only two items can be operated in tandem.

<u>The 3rd gate was never included in the modeling (i.e., modeled as open), and has been removed from the alternative.</u>

Page 4-30 – It is possible; however, the entrainment reduction benefits associated with this barrier operation could be offset by increase entrainment from Middle River. – It is not clear what is possible nor to what entrainment the sentence refers. Only by thoroughly reading the Alternatives report and the calibration study did this become clear.

<u>This statement has been clarified in the final report.</u>

Page 4-37 – escalated from 1985 values by a factor of 174% - there will be some who will wonder if you have increased 1985 values by a factor of 1.74 or have increased them by 174%.

<u>This statement has been clarified in the final report.</u>

Page 4-39 – Each ... value was then numerically averaged – many readers will not be able to decipher your meaning from the chart. Obviously you cannot average a single value, but are averaging the averaged-diversion values for each alternative.

<u>This statement has been clarified in the final report.</u>

General – the report uses a mixture of singular and plural uses of the word ‘data’. To this reader the word is always plural.

All uses of the word ‘data’ have been changed to plural in the final report.

2. **Scientific Validity.**

All methodology was well presented and documented except for the cost benefit analysis. It is clearly arguable that the straight percentage weighting for each diversion location and alternative should be weighted by the benefit of the water quality improvement to the use as well as by the volume of each individual use. Even the report acknowledges this shortcoming without justifying it in any way. An attempt at water quality benefit and volume weighting will serve as a point of discussion and provide a common method of adjustment for the discussion.

The benefit-cost analysis has been revised to be weighted for each diversion point.

3. **Alternatives Development and Analysis.**

While the weighting methods are a matter of discussion as to the relative merits by various stakeholders, the methodology was appropriate and well supported. Alternative that were eliminated were properly documented and the level of uncertainty was qualified were it was not possible to quantify.

4. **Water Quality.**

By necessity, water quality is qualified rather than quantified in the study. Water quality is quantified using electrical conductance (EC) as a surrogate for all water quality and other water quality parameters were qualified with the best known understanding of how they too would be affected. The study examines a rather low-flow water year which would provide conservative results and best quantify a bad case scenario, even if not the worst case. For a feasibility study this approach is satisfactory although a final study would require a longer time period and range of flow conditions. The study acknowledges that both a longer period and additional water quality parameters should be explicitly modeled for a final study alternative to be reached.

5. **Water Quality Modeling.**

The RMA2 hydrodynamic model and the RMA11 water quality model are quite appropriate for the hydrodynamic issues of the study domain. The codes of these models and numerous applications of the models have been well analyzed and reviewed in the literature; while no specific peer review has been made of this model application. Ideally one would like to have separate data sets with which to calibrate the model and then verify the model’s performance. Realistically, there is rarely enough data to even properly calibrate the model. In this case there were additional data collected in 2002 to supplement the ongoing data collection efforts of various agencies. These data allowed an adequate calibration of the model that revealed a few minor flaws for which there is simply not enough additional data to pursue corrections. The model is then used to examine the results of applying the alternatives to the model domain. The alternative simulations are then analyzed with consideration given to the minor flaws in the calibration. The uncertainties of the calibration and the application are well documented.

6. **Future Work**.

The study does a good job in identifying the next steps required for the implementation of pilot projects either implemented in part or on a larger scale. Clearly for future work it is necessary to continue field measurements so that this model or another model can be further calibrated and then verified. The data required for this work include stage, flow, and additional bathymetry refinement. Small scale demonstration projects, undertaken during the ongoing collection of data and model refinement, would serve to validate the future larger-scale restoration. There are still a number of chemistry questions to be answered before one can expect to properly model DOC or Hg effects. Additional work may be needed to even qualify the value of different forms of DOC.

Chapter 5 of the final report includes recommendations to better understand DOC and Hg effects.

7. **Additional Comments**.

At some point it is going to necessary to consider individual projects within the Delta as a whole rather than by themselves. Clearly something along the lines of the proposed Through Delta Facility could easily overshadow any individual project and render it unnecessary or contra-indicated.

Reviewer: #6

Review:

Comprehensiveness. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The report clearly outlines the objectives and evaluates the alternatives to meet those objectives. The process through which the alternatives were developed is clear except that it was not entirely explicit (to me) why alternatives were not explored for Big Break and Lower Sherman Lake.

Explanation of the dismissal of Big Break and Lower Sherman Lake is provided in the final report.

The opportunities to address the issues are for the most part well covered. However, on page 2.2-9, authors should mention that phytoplankton growth is generally light limited in the Delta (one reason habitat manipulations are thought to potentially improve production) and that grazing by clams exerts a strong control on phytoplankton productivity in the Delta-- which is another important consideration when manipulating habitats to improve productivity (this is mentioned but not in this regard here).

These comments have been incorporated into the final report.

What is meant by "ecosystem water quality" is not entirely clear to me from the report.

We could not find this term in the document.

Scientific Validity. Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

For the evaluation criteria, the definition of "residence time" is needed. Moreover, the use of water velocities (if possible) to evaluate potential effects on Egeria might be beneficial. For example, in the North Levee and Two Gates Alternative Ex.4.3-4, authors estimate a decrease in Egeria, but the effect of decreased velocities (which could increase Egeria) where north and western openings are closed (although mentioned) are not thoroughly evaluated or discussed.

A definition of residence time is provided in Chapter 3. Additional analysis on egeria and water velocities id recommended in Chapter 5 of the final report.

On p. 3-50: the description of assumptions about phytoplankton growth are vague... I realize this model and these assumptions were just used to get a conservative estimate of maximum residence time to prevent noxious algal blooms, but I have listed comments below that should be considered and caution the extrapolation of these results without incorporating other factors (like light attenuation and grazing).

Authors should mention that in the Delta, phytoplankton growth is generally limited by light availability. Nutrients are rarely limiting (Jassby et al. 2002). Specific questions and comments about this paragraph are as follows:
1)What is meant by "if light and temperature are just right" Do the authors mean if light and temperature are *optimal* for phytoplankton growth? Does this take into account light attenuation values characteristic of the site?

Clarification is provided in the final report.

2) What is the death rate attributed to? Is this supposed to mean loss to flushing (or transport from the system?) or loss to respiration or a combination? This should be clarified.

Clarification is provided in the final report.

3) Benthic grazing can be extremely important in habitats colonized by invasive clams and this fact should be stressed--especially because clams are abundant in Franks Tract.

Additional information is provided in the final report.

4)In the Delta, sinking phytoplankton are probably more prone to light limitation in stratified water columns than to limitation by cooler temperatures.

This comment has been included in the report.

Jassby AD, Cloern JE, and Cole BE. 2002. Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem.

Alternatives Development and Analysis. Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

I answer yes to all of the above except that a more thorough use of water velocity data could be beneficial (see answer to "Scientific Validity" above). Also, it seems some uncertainties discussed in the text might not be reflected in the screening criteria matrix (for example uncertainty discussed in final paragraph on 4-12 not reflected in matrix 4.3-4).

Additional analysis on egeria and water velocities id recommended in Chapter 5 and additional discussion on criteria is provided in the final report.

Water Quality. Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

The geographical coverage of salinity changes could be broader. For example, authors mention concern of salinity of Agriculture return water, so it would be useful to know salinity changes NE of Franks Tract near Ag intakes (I didn't see this in the evaluation). Also, if salinity changes are substantial within Franks Tract, that would be useful information because it could have ecological implications (e.g., for *Egeria* or *Corbicula* growth inhibition--which is mentioned in "Opportunities").

This comment will be considered in future phases of the study.

Water Quality Modeling. For the water quality modeling component:
Is the selected model appropriate for the level of analysis?
Is the selected model appropriately calibrated?
I am not a modeler so I can't answer these questions adequately.

Are the modeling assumptions clearly identified, and are they appropriate?
Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce

uncertainties presented? **The assumptions seem clear to me and uncertainties are acknowledged. Actions to reduce uncertainties are mentioned (like using a broader range of hydrologic conditions).**
According to the study has the selected model been peer reviewed?
I did not get this impression from the report

Future Work. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?
Refinement of the alternatives would benefit from the following steps (in addition to those mentioned in the report):
1) Exploring more detailed effects of flow regime on Egeria
2) Employing data on invasive clam distributions and abundance to refine alternatives
3) Evaluating more regional implications of flow regime changes on water quality

All of these comments will be considered for future phases of the study.

Additional Comments.

Exhibit 1-1: A legend would be helpful. Also a marker for the Delta on the state of California would be beneficial for anyone not familiar with the area.

A legend has been provided in the final report.

Great illustrations alternatives and levee constructions-very helpful!

Reviewer: #7

Review:

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The "desired outcomes" (project objectives and feasibility study objectives) are clearly identified individually, separate from one another, as though compiled from multiple stakeholder and technical advisory groups. The project study purpose, and list of project objectives is quite complete. There is some inherent ambiguity in describing the underlying nature of the proposed interventions for the flooded islands: the study includes some habitat restoration components, but it is not overall an "ecosystem restoration", and does not claim to be. The purpose seems to be enhancement of beneficial uses (habitat, recreation, water quality, etc.) within the constraints of the stated problems of flooded subsided delta islands. It seems that the generic term "rehabilitation" applies to this approach. The integration of desired individual outcomes for the project's "site concepts", articulated as coherent, multi-faceted alternatives, is less clear. The design features of alternatives are not entirely comprehensive in that they do not stress <u>integration</u> of specific engineered design approaches to tidal marsh, recreation, flood control, SAV control, etc. They seem to function as a suite of co-located semi-autonomous projects, related as in a specific geographic area master plan. The alternatives appear to be composites of subordinate project designs, rather than integrated wholes.

<u>Additional information regarding integrating project objectives with alternatives is provided in Chapter 4.</u>

The level of explanation is somewhat uneven. There seems to be relatively more discussion of uncertainties, problem statements, and hypotheses (e.g., subjects such as DOC, methylmercury transformation, fish ecology, nonnative SAV ecology) than applications of expertise and demonstrated technology in the design of alternatives to address them. For example, there is an ample scientific literature (including gray literature) on tidal marsh restoration, vegetative stabilization of shorelines or dredge material islands, but there was very little discussion of design approaches, materials, methods from other regions applied to the Delta oligohaline, microtidal, relatively sediment-starved environment. I did not find the level of "site concept" discussion of tidal marsh restoration technology and conceptual designs to be as specific or detailed as the explanations of uncertainties about SAV ecology, fish behavior, methylmercury, etc. For example, despite the repeated desired outcome for "dentritic channels", there was no discussion about how they could be feasibly formed, or even whether they would form. This is remarkable since all alternatives propose creation of 420 acres of tidal marsh in Little Frank's Tract, with no variation in methods or materials, and almost no explanation beyond the thumbnail design criterion of filling (with what? Sand? Mud?) to -0.5 NGVD (p. 4-17). There was also little or no discussion of re-engineered shoreline configuration design, relationships between restored tidal marsh and amenity beaches, and possible design alternatives for setback levees (surprisingly limited to rock or concrete, with limited explanation). The level of detail for bioengineering (soft shoreline stabilization) techniques was good, as was tidegate hydrologic design, but these contrasted with the relatively cursory treatment of tidal marsh and riparian woodland/scrub restoration methods.

I don't think the discussion suffered from lack of (or weak) definitions. The rigor of discussion was more often limited by repetition of defined terms like "dendritic tidal channels" without delving into what they mean in an applied restoration/rehabilitation conceptual design.

<u>Additional information regarding construction of tidal marsh and riparian woodland has been added to Chapter 2. If restoration features of this project move forward, detailed restoration plans will be developed that describe methodologies for implementation.</u>

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

The uncertainties were very thoroughly dealt with, and they may have been emphasized so much that they called into question whether there was sufficient understanding of the problems, and corrective technologies, to justify intervention at all. The emphasis on complex factors affecting outcomes (for example, non-native fish and SAV relationships) was perhaps excessive, leading to perplexing statements such as:

Overall, there is no definitive information on the relative weight of opportunities and constraints associated with the creation of additional shallow water habitat or increased habitat diversity within the flooded islands, with or without colonization by SAV, which would clearly demonstrate the population level benefits to the native fish assemblage" (p. 2-23, Draft Report)

On the face of it, this unqualified conclusion undermines justification and basic feasibility of one of the principal objectives of the project, diversification of subtidal and intertidal aquatic habitat (1-3), an opportunity defined on p. 2-21. The scientific validity of stated opportunities and constraints seem to pass each other by. This is echoed, for example, in discussion of *Egeria* invasion problems stated on pp. 2-22 to 2-23 (almost all scenarios worsen uncontrollable *Egeria,* with no effective control method identified). This apparent pessimism stands in marked and unexplained contrast with the approach to methylmercury uncertainties on p. 2-11. There, the complexity of ecological processes governing the problem is interpreted to provide "some level of assurance" that intervention will not make methylmercury problems worse. Comparable "assurance" is not the interpretation for SAV and fish interaction complexity, even though there is a solid case that matters may be worse regardless of alternatives selected. More editorial consistency of scientific judgment would be appropriate here.

> <u>Not all alternatives definitively worsen egeria, it tends to be rather speculative for this study. Comparable levels of assurance cannot be assessed for all conditions/issues because the levels of uncertainties can vary. Additional analysis is recommended in Chapter 5 of the final report to address critical uncertainties.</u>

Given some of the fundamental uncertainties identified, evaluation criteria and design rationales should stress practical affirmative aims for decision-making and design, working around uncertainties now as much as possible, rather than trying to resolve them with future studies/adaptive management. In other words, stress what is known or judged likely to work, based on either local experience or comparable experience in other regions. In the case of the quoted sentence above (2-23), what would "clearly demonstrate the population level benefits" mean? How "clear" or certain do the lead agencies need to be in order to make a decision about what to do for fish? In an ecological engineering context, there is an inevitable (low) limit to predictability and theoretical adequacy, and a natural role for professional skill, judgment and expert opinion to pick up where scientific certainty leaves off.

Some assumptions of the study seem to be scientifically validated by repetition more than reference to scientific literature. There is a widespread assumption in the report that high current velocities are a threshold limiting physical factor for *Egeria* establishment. It is not at all clear, however, whether this apparent relationship is based on a restriction of *Egeria* colonization by mobile substrates and high shear under high current velocities, mechanical injury or inhibition of *Egeria* growth under high velocity currents, or erosion of established colonies. If the effect of high current velocities on *Egeria* is merely on frequency of successful founder colonies, the interpretation of a velocity threshold for maintaining *Egeria*-free subtidal habitat may be in error. Progressive clonal expansion from well-anchored, continuous stands may spread from sheltered sites to progressively higher-energy sites. This does indeed appear to be consistent with patterns of subtidal SAV bed progradation in the aerial photos of Frank's Tract.

> <u>For detailed information regarding egeria, please see the Baseline Report. Regarding threshold limiting physical factors for this species, elevation and energy and substrate stability would all affect egeria. Exposed horizon and wave action decreases the presence of egeria. Egeria can live in depths down to 12 to 14 feet and up to 3 to 4 feet as measured at high tide, but generally only down to 9 feet in Franks Tract.</u>

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

The alternatives development seemed to focus on engineering levee and water control gates, emphasizing effects on water quality (salinity), with ecosystem and recreational elements as accessories or amenities. Any landscape-level considerations of alternatives design and function appear to be driven by the levee and gate engineering. The alternatives flow directly from the "toolkit" with little evidence of landscape ecology or large-scale geomorphic design. The overall harmony of main effects and side-effects of the large-scale designs were not well explained in terms of basic project objectives in "discussion of benefits and impacts". For example, the opportunities and constraints discussion emphasized substantial public interest in open water navigation and sport fisheries (2-31), and the ecological problems of *Egeria*. The alternatives emphasized closing of levee breaches and construction of tidegates, while acknowledging that increased sheltering of subtidal beds by closed levees and gates would likely increase *Egeria* spread, and restrict navigation. How were these factors weighted? Were these "overriding project goals" (p. 1-4) weighted equally, or do some override others? Were the constructed recreational amenities (mooring and docking areas, launches, beaches) and emergent wetland construction (habitat levees, filled restored marsh) considered to be internal "mitigation" or counterbalancing factors for the major side-effects on navigation and SAV impacts from channel engineering? There seems to be omission of an executive rationale for trade-offs, priorities, or overriding considerations, given the even-handed treatment of opportunities and constraints earlier in the document. An explicit, plain-language comparison of alternatives, with values and judgments of priorities made clear, would be appropriate.

<u>See Chapter 2 for a summary table linking opportunities and constraints to objectives and Chapter 4 for a discussion regarding relationship between alternatives and objectives.</u>

It was surprising to find that no alternatives addressed one of the major constraints identified for flooded islands: excessive wind-wave energy due to unbroken fetch and excessive water depth. The only design approach for mitigation of excess wave energy was construction of habitat levees, and only "habitat" levees with cores of concrete or rock (no alternatives with habitat levees emphasizing soft stabilization of low-angle slope earthen materials). The concept of breaking up flooded islands with marsh islands (or archipelagos of islands) was not considered, and "avian habitat islands" were rejected (p. 3-6) with surprisingly little analysis or discussion; the main reasons given were vulnerability to erosion and large fill requirements. These potentially important habitats seem to be rejected with too little reason. These were not compared, however, with total cost and fill requirements for hard-core habitat levees. Alternative marsh or upland island designs with varying degrees of shoreline armoring were not considered, even though rock and concrete cores were standard features of "habitat levees" in all alternatives. This appeared to be an engineering bias towards a favored design approach for structural habitat levees (wave barriers) over widely dispersed marsh islands and upland islands (wave attenuation, fetch reduction). Trade-offs between relative wildlife and habitat diversity benefits of marsh islands, terrestrial islets, and habitat levees (or variable combinations) would have been worthy of discussion.

<u>See Chapter 3 for additional discussion on engineering, stability, and sustainability.</u>

An alternative, intermediate design blending marsh islands and habitat levee concepts would be to combine deepwater channel dredging with side-cast submerged "levees" acting as shallow subtidal to intertidal platforms for tule marsh, within flooded islands. This would generate a skeletal channel-marsh structure that would serve navigation/recreation interests in low-*Egeria* deepwater channels, provide emergent marsh/open water edge habitat, and impede open-water wave propagation (increase bed roughness). This local cut/fill approach would require less net fill import than island construction. It would be no more or less artificial than islands or habitat levees.

<u>The reviewer's suggestion will be considered in future phases.</u>

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

Water quality is outside my expertise, but it was evident that the introduction used somewhat exaggerated non-technical terminology and imagery to describe current water quality issues in the delta: on page 1-1, the Problem Statement referred to salinity as a function of "high-salt content *ocean water* with daily tidal action", in a sentence beginning with "Salinity concentrations *within* the Delta" (emphasis added). Similar references to "sea water intrusion" and "a *wide range* of salinity" (p. 1-2) are found elsewhere (p. 2-3). The oligohaline (not "saline") estuarine nature of the delta wetlands, and complex estuarine salinity gradients are not well described by this language. No context of natural salinity variation (marine, lower estuary, upper estuary) or regulatory salinity thresholds (standards, drinking water) is presented along with this introduction, making the reference lopsided. Salinity values stated on p. 2-25 are questionable. While this misleading ambiguity may have been unintentional, for non-technical decision makers who may review only the introduction and recommendations, this introductory discussion is disorienting. Seawater intrusion probably *should* be discussed in terms of marine transgression and accelerated sea level rise over a 50 to 100 year planning framework. There is surprisingly no discussion of sea level rise and salinity intrusion (marine/estuarine transgression) in the introduction, constraints discussions, or alternatives designs. This is quite anomalous for coastal planning in California (or any other coastal locality).

5. **Water Quality Modeling.** For the water quality modeling component:
    a. Is the selected model appropriate for the level of analysis?
    b. Is the selected model appropriately calibrated?
    c. Are the modeling assumptions clearly identified, and are they appropriate?
    d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
    e. According to the study has the selected model been peer reviewed?

(Water quality modeling is outside my expertise)

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

The outline of pilot project actions (5.3.3) does not include any design concept information comparable to that given for temporary rock barriers, pocket beaches, and levee/gate designs. No variation in methods or materials for creation of marsh or riparian woodland is identified, or for establishment of dendritic or simple tidal channels. Variation in methods and materials would be expected for adaptive management approaches to habitat restoration. Despite the predictable increase in SAV with greater sheltering due to levee reconstruction (closing), there appears to be no identification of monitoring of *Egeria* spread response to pilot project construction. This would be informative for deciding whether to carry over the pilot study to full implementation.

7. **Additional Comments**. See below.

Specific comments

Page (draft)	subject	comment
2-7	DOC	Text explains that phytoplankton productivity is "necessary to support a Delta food web of diverse and desirable species", and also "believed to be an important source form of reactive DOC potentially leading to THM formation". Despite discussion of "potential approaches", there is no clear guiding principle for alternative designs regarding context for increasing or decreasing phytoplankton productivity; ambivalent opportunities and constraints discussion dangles rather than guides. Deferred study (adaptive management) does not inform current alternatives design and outcome (p. 3-6). <u>Discussion of operable gates is provided in Chapter 3 as potential means for controlling residence time and flushing phytoplankton to the west Delta. Potential ecological response is complex and largely unknown, therefore, adaptive management recommendation is provided.</u>
2-10	meHg	Reference to important "recent findings" (not available in standard reviews from last several years) should have references in literature cited. <u>Personal communication referenced is provided.</u>
2-12 to 2-14	meHg	Given complexity of meHg, and need for working hypotheses that consistently and actively guide design principles for comparison of alternatives, there is a need to summarize best professional judgment or working assumptions for site concept designs. There is a gap between this discussion and alternatives design; they seem to bypass. <u>Recommendations are provided in Chapter 5 of the final report for additional analyses.</u>
2-15	Tidal marsh	Note recent taxonomic nomenclatural changes for *Scirpus*, in which subgenera are elevated to genus rank: "tules" are placed in *Schoenoplectus*, "bulrushes" are placed in *Bolboschoenus*. "Threesquare bulrush" is the common name of *S. americanus* (formerly *Scirpus olneyi*), not *B. robustus*. <u>The common name for S. olneyi in the document has been corrected. Other comments noted, latin names conform to Jepson Manual and have not been changed in this document.</u>
2-15 2-19	Tidal mudflat, Sand dredged materials	"Tidal mudflat" is discussed as a habitat conversion opportunity, but most of the available dredged material from the Delta, as I understand, is likely to be sandy or sand. Both mud (clay-silt) and sand have potentially valuable habitat restoration functions, but they differ, and are hardly equivalent. There construction traits contrast strongly. Mudflat is not really "equivalent unvegetated substrate" comparable with rootwads for most wildlife species; shorebirds do not forage or rest on rootwads (large woody debris). <u>Dredged material located on Decker Island is silty sand. Anchored rootwads would not necessarily be a key habitat component but rather a means to provide a buffered backwater area to protect the mudflat from wave erosion and allow suspended material to settle out.</u>
2-15 2-18	Large woody debris	I strongly agree that including large woody debris (snags, rootwads, logs "recycled" from felled large Eucalyptus) in wetland restoration designs would be highly appropriate and useful. The elimination of large woody debris sources in the delta is as ecologically significant as sediment starvation due to dams, in my opinion. The value of large

* Responses to comments are indicated as underlined text.

		woody debris in the upper estuary habitat is probably as significant as it is in nontidal freshwater rivers. Standing boles (snags) prostrate large wood (rootwads, logs), and woody debris jams, should be considered in levee and tidal freshwater marsh designs. An opportunity paragraph has been added in Chapter 2 that discusses including woody debris in restoration design.
2-16	Mosquito production	Rather than focus only on mosquito predators, physical factors that limit survivorship of mosquito larvae (e.g. pond fetch, wind-wave turbulence, tidal range, tidal circulation) should be discussed with equal or greater emphasis in context of tidal marsh. The reviewer's suggestion will be considered in future phases.
2-17	Tidal marsh	Technical variations in established biotechnical stabilization designs should be considered as adaptive management for "scaling up" successful techniques to sites the size of Frank's Tract, with due attention to economy of scale. "Setback levees" and "habitat levees" described in other DWR contexts do not have engineered or armored cores, so this increased design cost should be critically explained and justified, with lower-cost alternatives considered. The reviewer's suggestion will be considered in future phases.
2-18	Trees, levee stability	References to scientific/technical literature are needed for tree/levee instability "belief". Critical evaluation of the potential destabilizing effect of isolated trees on levees, compared with continuous established canopy and root networks of riparian woodland, would be quite helpful in this context. This statement has been removed in the final report.
2-20	Fish habitat	Again, complexities of ambivalent or ambiguous hypotheses are not reconciled as a "best professional judgment" or "working hypothesis" for habitat design guidelines, or even leading alternative guidance principles in "potential approaches". Are uncertainties overstated, or is the science really this muddled? Is there enough science to make decisions or set up focused tests of restoration hypotheses? An explicit statement would be helpful. "Potential approaches" (2-24) discussion is anomalously simplified, vague, general, and brief compared to the technical preambles about uncertainties; it talks around a conclusion. But this is the section that really should integrate and guide alternatives design for fish. Lack of consistent guidance See Chapter 2 for additional discussion and summary table on potential approaches.
2-24	Egeria/SAV	"Algal mats" probably refer to epiphytic filamentous algae. "Mats" are planar filamentous algal masses, floating or bed-attached. Waterfowl (diving ducks) probably do not utilize sediments over the entire depth range of *Egeria* (foraging in top meter/2 m?). Salinity tolerance stated of "10-12 ppm for few days" is perhaps ppt, because even nonhalophytes would not physiologically "feel" 12 ppm. Algal mats discussion has been clarified. Typographical error regarding ppm change to ppt has been corrected.
2-25 see also 2-28, 3-2, 4-4	Egeria/SAV sand	Much more discussion is needed for statement about Egeria establishment limitation on unconsolidated substrate (sand) and restoration design potential. This implies a major design feature for the "toolkit", where SAV control is otherwise very pessimistic. Integration of several features mentioned in different parts of the document (deepwater dredged channels for recreational boating, placement of sandy dredged materials for habitat) should be integrated to design experimental innovative channel habitats to test resistance to SAV invasion. Bed substrate mobility in deep channels backfilled with sand (banks defined by constructed marsh or habitat levees)

		should be considered as a multi-function anti-*Egeria* design. Use of subtidal sand deposition (as opposed to dredging) to smother Egeria beds should be considered, since the resulting mobile substrate would be potentially less conducive to recolonization, compared with consolidated substrates in high-energy subtidal environments. Integrate navigation and restoration discussions. Recommendations are included in Chapter 5 of the final report to address Egeria issues/effects.
2-25 2-26	Egeria/SAV Native SAV	While it is true that "native SAV cannot be achieved by hydrodynamic means alone", neither approaches nor alternatives discuss possible experimental methods of establishing native SAV (in constructed "backwater" conditions) to pre-empt (exclusion by manipulated invasion sequence) SAV space. An opportunity paragraph for restoring native SAV has been added in Chapter 2.
2-26 2-27	Egeria/SAV Corbicula	Relationship between *Corbicula* and *Egeria* should be discussed. Does *Egeria* preclude *Corbicula* beds? Does *Egeria* removal increase *Corbicula*? Which is worse in what context? Is there any evidence that Mildred Island is actually resistant to *Corbicula* invasion because of environmental attributes, or is the invasion pattern stochastic, circumstantial? Research effort should be commensurate with potential for environmental effects. Discussion on relationship between Egeria and Corbicula has been provided in the final report.
2-28 2-29	Navigation Tidal wetland restoration	The discussion of opportunities for boating access "reaches" toward innovative tidal marsh restoration and landscape-level wetland design, but this is not reflected in corresponding tidal marsh discussion sections. The clear potential for integration of navigation and tidal wetland restoration should be developed, and reflected in alternatives designs. Integration of navigation and tidal marsh restoration was not envisioned in this study primarily due to the damage to tidal marsh caused by boat wakes. Navigation and other boating/recreational improvements are discussed separately.
2-30	Navigation dredging	Why would costly "repeated channel dredging" be necessary in apparently sediment-starved, static bed of Frank's Tract? Suspended sediment driven shoaling is only one form of shoaling. Another means of shoaling relates to the potential for wind-wave re-suspension and resultant deposition. While the jury is still out on the matter of the former means of deposition, the latter method is certainly of high potential to occur at FT. More specifically, considering the shallow nature of FT coupled with the frequency of almost daily high wind events, the potential for wind/-wave driven re-suspension is believed to be quite high. Such potential leads us to believe that dredged channels would likely silt-in from such deposition.
2-31	Open water Sport fishing	Discussion should consider spatial segregation of "striper hole" habitat (open water sport fishery areas) and native-priority fisheries and wetland habitat. Some areas could be dedicated to recreational amenities (mooring, beaches, open water navigable sport fishery areas, high maintenance), while others emphasize wetland, channel habitat for native species to minimize overall conflicts in priorities (see "strategic location" approach for Egeria on p. 2-34). The approach of "alternative recreation experiences" of tidal marsh is simply not credible for the existing public interest in sport fisheries and recreational boating (see p. 2-31), and seems disingenuous. For the most part, the alternatives did address recreation and habitat

		amenities separately. We were merely suggesting that there may be a further opportunity for those with a slightly different interest to enjoy tidal marsh either in a passive or active way. We don't believe this statement is disingenuous.
2-38 3-29	Erosion, sand beach, Beach orientation	Erosion of beaches is not just a function of wave energy; it is strongly influenced by shoreline configuration and nearshore slope. Indented "pocket" shorelines can trap sand so alongshore transport is precluded, and nearshore slope can be flattened enough so that offshore (deepwater) losses are minimized. Low-energy beaches tend to become vegetated; open sand favored by recreation is maintained by periodic high energy erosion/accretion cycles. Beaches should also be considered as habitats (nesting, loafing); not all constructed beaches should be recreation-priority, or designed solely for recreation. Beaches should be considered in context of island habitats as well as recreation (pp. 3-5, 3-9) with integration or segregation of design concepts, as appropriate. Emergent sand landforms (emulating splay deposits) can be important restored habitats, transitional from marsh to riparian woodland and low dunes. We agree with the opinions expressed by the reviewer. The location and extent of the pocket beaches were determined with these in mind. We concur that beaches in low-energy areas will vegetate. For instance, the beaches along the west side of Franks Tract will tend to vegetate more so than the eastern pocket beaches because of the higher wave exposure experienced by the eastern beaches.
3-5 3-27, 5-6	Habitat levees	The description of habitat levees invokes the name applied by earlier DWR/USFWS design, but design drawings all feature costly structural (concrete/rock) components that are not discussed or justified in context of the text until p. 5-6, with no explanation. The need and purpose of rock/concrete walls is not clear, nor is the justification of this added feature over alternatives emphasizing low-angle slopes of earthen fill, and vegetative stabilization. The primary need for a "core" (be it rock or concrete) was to ensure the levees could perform their primary duty – diverting water flow. While it is true, perhaps one could use larger earthen fill structures, the resulting footprint would most likely be significantly larger and thus require the use of likewise significantly greater amounts of fill.
3-11	Residence time, algal bloom	Nutrient loading is a highly important factor in calibrating relationships between estuarine water residence time and algal blooms during summer. Comparing widely contrasting salinity and settings may generate excessive noise in data analysis. Comment noted, the authors acknowledge the complex nature of residence time and algal blooms. Discussion of the model was provided for preliminary screening and additional analysis is recommended.
3-23	Marsh size, perimeter (edge)	The relationship assumed for marsh area and "dendritic tidal marsh" needs critical review. The illustration (see all figures of Little Frank's Tract) of historic mature tidal sloughs formed in accreted sedge/tule peats is very misleading in the context of constructed freshwater tidal marsh habitat. There is, to my knowledge, no supporting evidence that placement of mineral sediment, especially sand, is amenable to formation of this type of channel system either in the Delta or anywhere in the Corps of Engineers national program of creating marsh island habitats with dredged materials. This illustration is not instructive without text explanation. The discussion should discuss whether it is known whether it is the channel habitat structure itself, or the marsh/open water edge structure, that is known to be associated

* Responses to comments are indicated as underlined text.

		with specific ecological functions or benefits. If marsh/open water edge is a key variable, then other marsh restoration configurations should be considered, especially if they are more compatible with known constraints of marsh construction. Additional explanation of tidal marsh habitat is provided in the final report. The exhibits (4.3-1, 4.3-3, 4.3-5, & 4.3-7) that include Little Franks Tract are intended to be preliminary sketches of the potential area that could be converted to tidal marsh. They are not intended to be design or as-built drawings of the tidal marsh /slough network nor are they intended to depict historic tidal sloughs of Little Franks Tract. (Similar to the blue line that depicts the gates/barriers.) The material (likely from Decker Island) that may be used to create tidal marsh is silty-sand which is appropriate for creation of tidal marsh. Design details for restoration components would be contained in a separate document that provides specifics regarding proposed configuration, elevations, plant materials, to what degree natural colonization would be utilized, use of woody debris and other materials, sustainability, maintenance, and likely ecological functions and values.
3-30 and all "Discussion of Benefits and Impacts" , Section 4, Section 5	Summary; integration	A table or bullet list can be used effectively to summarize atoms of information, but these are not effective for actual integration of summarized discussion. Section 3.6 needs explicit explanation of the decisions and rationales for the framework of alternatives brought to full feasibility evaluation, and reasons for screening out others. Policy and value issues should be made explicit in integration discussions comparing alternatives, especially where major trade-offs are made. Additional explanation and discussion is provided in the final report.

Reviewer: #8

Review:

The subject report describes a series of projects that together have the potential to improve drinking water quality in the southern Delta, as well as address issues of aquatic habitat for native species in the western Delta.

Unfortunately, the quality and level of analysis, and modeling are insufficient to assess if the putative improvements will be realized.

This review is confined to drinking and environmental water quality aspects of the report, including, where appropriate, modeled aspects of water quality.

8. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The report is significantly lacking in several key areas related to water quality, as described below. The justification for alternative selection frequently cannot be interpreted in the current report because the underlying assumptions are invalid. The water quality assessment should be repeated using the correct assumptions, adequate model performance verification, and an expanded suite of evaluation criteria.

9. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

The scientific basis used for evaluation of prospective improvements in two important aspects of water quality, DOC and mercury, are deeply flawed and should be corrected, and the analysis repeated with the correct information.

Organic Carbon:
Dissolved organic carbon (DOC) presents problems for drinking water utilities because it may form regulated byproducts (THMs and other disinfection byproducts [DBPs]) change disinfectant demand, or clog membranes. The report correctly describes DOC as arising from a variety of processes and representing a myriad of chemical types, and possessing important qualitative differences that affect DBP formation. However, the authors do not appear to be aware of the recent research in the Delta that has investigated the sources and composition of the DOC with respect to DBP formation.

The analysis in the report incorrectly asserts that phytoplankton are the dominant source of DOC in the Delta. This is probably the result of confusion between the sources of OC (usually particulate organic carbon) that supply essential nutritive material to the aquatic food web, and DOC, which has lower direct nutritive benefits to the food web. The text of the report often inappropriately interchanges the terms OC and DOC. For example, the report, without attribution, states that "River sources of organic carbon appear to dominate in the winter, whereas biological processes (phytoplankton growth) in the Delta appear to dominate in the spring and summer (p2.2-8)." It further states that "Phytoplankton are also believed to be an important source form of reactive DOC potentially leading to THM formation (p2.2-9)." Neither of these statements is correct with regard to DOC.

<u>The report DOES NOT assert that phytoplankton are the dominant source of DOC in the Delta. The terms DOC and OC are not interchanged. The word 'important' has been removed from the statement "Phytoplankton are also believed to be an important source</u>

form of reactive DOC potentially leading to THM formation" and citations are provided for both statements in the final report.

Extrapolating based on the flawed assumption that DOC arises from phytoplankton, the report surprisingly concludes that invasive clam species will help ameliorate changes in DOC production by consuming phytoplankton: "Consequently, although invasive clam species are generally acknowledged to be undesirable,…..their influence through algal consumption provides some assurance that the potential strategies *would not likely alter THM formation potential* in water supplies because *any increased algae production would be consumed by clams* (2.2-12; emphasis by reviewer). This assertion is misinformed, irresponsible, and disingenuous. If this is the basis for modeled changes in DOC, the model analysis is deeply flawed. This appears to be the case (p3-35). More recent models of phytoplankton production are available for the Delta that explicitly include issues of light limitation (3-50).

The statement regarding clams has been removed in the final report. Changes in DOC were never modeled. A discussion on light limitation has been included in the final report.

Contrary to assertions in this report, recent analyses of historic data indicates the majority of DOC added in the Delta is added in the winter and spring, with smaller amounts added in the summer and fall. Most active researchers in the field agree that the dominant sources of DOC in the Delta are Delta peat island drains and wetlands, comprising 50% of the DOC added in the winter, and 0-25% added in other seasons. The amount added by each of these sources is still under investigation, but recent evidence indicates wetlands are a much larger contributor than previously thought. Phytoplankton, often light limited in the Delta, are thought to be a less important source of DOC from a variety of lines of evidence.

The report DOES NOT assert that the majority of DOC added in the Delta is in the summer and fall. The commentor's statement that "Phytoplankton, often light limited in the Delta, are thought to be a less important source of DOC from a variety of lines of evidence" needs to be qualified from the standpoint of drinking water or food web as phytoplankton have been documented to be important to overall ecosystem productivity (citations provided in the final report). Additional discussion on phytoplankton being light limited has been added to the final report.

Several presentations at recent CALFED Science conferences calculated the DOC export from various land uses and from Delta phytoplankton production. They found that per unit area, wetlands export 10-20 times the amount of DOC than from peat island agriculture or phytoplankton. Since agriculture occupies a large fraction of the area of the Delta, it can be expected to contribute a much larger fraction of DOC than algae. The report discounts the potential effects of wetlands by saying: "How wetlands function affect DOC production, timing, and interactive influences of hydrodynamics on the transport of DOC from wetlands is not well understood (2.2-13)." Although on the surface, it appears that the extent and position of the wetland restorations contemplated in Frank's Tract will not have a significant impact on DOC, the effect should be accurately assessed using the hydrodynamic model and reasonable assumptions for DOC export from tidal wetlands.

The report acknowledges wetlands, peat island agriculture drainage, and phytoplankton as sources of DOC. The report DOES NOT discount the potential effects of wetlands, it simply states acknowledges the complexities and uncertainties associated with production, timing, and interactive influences of hydrodynamics on the transport of DOC from wetlands. Recommendations for additional analyses of DOC are provided in Chapter 5 of the final report.

Mercury:

The statement suggesting "clean inorganic sediments" support high concentrations of bioavailable Hg whereas anoxic organic sediments have high sulfate reduction rates results in wetland restoration not greatly affecting MeHg production is a spurious conclusion (p2.2-14). Clean inorganic sediments tend to have pore waters that are significantly lower in total Hg compared to organic sediment pore waters. The relative

proportion of "bioavailable Hg" is usually higher in inorganic sediments because organics can bind large quantities of Hg2+ into organic complexes. However, organic sediment pore waters almost always have much higher concentrations of all forms of Hg compared to inorganic sediment pore waters. Furthermore, current studies are investigating the role of organic matter in mobilizing sediment bound Hg into the water column and thus the food chain.

<u>The report DOES NOT make CONCLUSIONS regarding the above referenced statement (clean inorganic sediments), it simply acknowledges that this is one more important piece of the puzzle that needs to be considered. A discussion on pore water is included in the final report.</u>

The contention that there are assurances that changes in hydrodynamics may not substantially alter existing MeHg interactions is irresponsible as it presumes knowledge not yet available (p2.2-16). That the central Delta has very low biota concentrations of Hg despite the area seemingly being a prime location for Hg methylation is an area of active investigation. It could be just one variable that has created this anomaly and any change in management could tip the balance and have a significant impact on methylation in the area.

<u>The report states that MeHg interactions MAY not be substantially altered and acknowledges the uncertainties. Additional analysis is recommended in Chapter 5 of the final report.</u>

It is wise to propose using "clean" sediments to reduce the potential effects of construction activities using Hg-laden sediments (p2.2-16). However, it is erroneous to suggest that clean fill could "eliminate" MeHg formation. MeHg tends to be about 0.1% - 10% of total Hg depending on environmental conditions, regardless of total Hg concentrations. Therefore it is wise to reduce the total Hg and thus reduce MeHg concentrations, but environmental conditions will govern the percentage of MeHg over as much as 2 orders of magnitude. It is important to remember that no soil is Hg free and there will always be plenty total Hg to produce MeHg. Using cleaner fill will reduce the effects compared to Hg-laden dredge but cannot be said to "enhance" the food web over current conditions.

<u>The report DOES NOT state that clean fill will eliminate MeHg formation, it does use the words 'reduce' and 'minimize'.</u>

The work of Mark Marvin-DiPasquale on reactive Hg in sediments is very important (p2.2-18) but so is speciation in overlying waters, particularly photolytic effects. Also salinity/organic matter influences and water column mixing effects on photoeffects and reactive Hg cycling are very poorly understood in this environment.

<u>Additional discussion on photoeffects is provided in the final report.</u>

There is a range of sulfate levels that is optimal for Hg methylation (p2.2-17), and altering the salt distribution in the Delta may help reduce sulfate levels below that range but that is not known. Redox in soils with fluctuating water tables may govern sulfate levels in the interior delta more than imports.

<u>The report uses the words 'may' and 'potential'.</u>

In conclusion, the authors have failed to incorporate even some extremely fundamental aspects of DOC and Hg geochemistry into their water quality analysis, and have not incorporated basic knowledge of geochemical processes in the Delta into their analysis and modeling. Accurate assessment and modeling of the effects of hydrodynamic and restoration changes should be conducted using correct geochemical assumptions.

<u>The reviewer seems to suggest that the modeling of DOC and mercury is flawed, when in fact there was no modeling of these constituents as part of the current phase of this study.</u>

10. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly

documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

As suggested elsewhere, the criteria for analysis should be broadened to include several parameters:

a) **The distribution of residence time in model grid points rather than bulk residence time should be used for evaluation as this impacts the geochemical and ecological benefits.**
b) **Source and specific drinking water parameters should be included in the modeling and analysis; most importantly SUVA (defined elsewhere) and bromide.**
c) **Uncertainties are minimized or not addressed adequately in the current report. Model errors in replicating EC in the central Delta, while acknowledged, are not incorporated in a systematic way in the evaluation of alternatives. Uncertainties should be assessed, propagated, and reported in graphical presentation of results.**

<u>Modeling of residence time did consider the variation of residence time across Franks Tract, see Alternative Modeling Report. The reviewer's suggestions have been included as recommendations and shall be considered in future phases.</u>

11. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

Discussed in next section.

12. **Water Quality Modeling.** For the water quality modeling component:
    a. Is the selected model appropriate for the level of analysis?
    b. Is the selected model appropriately calibrated?
    c. Are the modeling assumptions clearly identified, and are they appropriate?
    d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
    e. According to the study has the selected model been peer reviewed?

The modeling efforts described in this report, while commendable, are incompletely calibrated, do not accurately represent the current flow system, and make assessments based on flawed assumptions.

Modeling efforts should be modified in several significant ways:

a) **The modeled time period should extend over several years, and should include successive dry and wet years, and transitions from successive dry years to a wet year.**

<u>Agreed, these recommendations are included in Chapter 5.</u>

b) **The model should extend over the entire year. Even though the focus of the project is salinity improvements at drinking water intakes, and there is lower salinity in the winter, there is a possibility that the high DOC levels in winter may occur at the same time as elevated salinity. Higher DOC and salinity together (even if salinity is only modestly higher than current winter levels) have the potential to increase DBP formation in these waters.**

<u>Agreed, these recommendations are included in Chapter 5.</u>

c) **The geographic extent of the model should be expanded to include the effects on the eastern Delta because the modified flowpaths described in the report have the potential of exacerbating dissolved oxygen problems in the SJR deep water ship channel.**

This suggestion will be considered in future phases.

d) **The model should be run for the decade or more where EC, DOC, SUVA are available at several interior Delta stations and the results compared to actual values. The model should be able to replicate variability in these important parameters under historic conditions to be suitable for scenario testing. The error should be included in the uncertainty assessment.**

Agreed, these recommendations are/have been included in Chapter 5 of the final report.

e) **I suggest that the model explicitly include model assessment of changes in bromide (the most problematic drinking water issue for salinity) and Specific Ultra Violet Absorbance (SUVA). SUVA provides a rough estimate of the sources of DOC, particularly from peat islands, and there is a long time series available for model calibration.**

Recommendations for additional analysis have been included in Chapter 5 of the final report.

f) **In addition to bulk residence time, the frequency distribution of residence time in model grid elements should be used to compare alternatives. The model should be modified to provide this output. This is necessary because a rapid flow across, for example, the eastern edge of Frank's Tract may result in a short bulk residence time for the Tract, but residence time in some areas may increase significantly, altering the geochemistry and habitat quality of those areas.**

See Model Calibration and Alternatives Modeling Report.

g) **As described above, model assumptions are deeply flawed and must be corrected.**

Recommendations for additional analysis have been included in Chapter 5 of the final report.

h) **Model results for Big Break and Sherman Lake that incorporate potential restoration scenarios should be presented to assist in assessing the potential ecological and geochemical effects.**

An explanation of dismissal of Big Break and Lower Sherman Lake is provided in the final report.

13. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

Many suggestions for improvement of current and future work are presented elsewhere. One significant deficiency of the current analysis, and one that should be incorporated in to future analyses is the potential to alter sediment fluxes of constituents of concern both during and following restoration. It is self-evident that dredging and sediment placement will alter the DOC and Hg dynamics. However, one aspect not considered is the geochemical effects of sediment compaction. While the high likelihood of sediment compaction is noted in the report, it does not appear to be considered that this process will eject pore fluids into the overlying water. Ejected pore fluids will likely be enriched in DOC and Hg because of the organic matrix and reducing conditions. This ejection has the possibility of lasting for several years until the sediments are fully compacted.

A discussion of sediment compaction and pore water effects has been included in the final report.

14. **Additional Comments**.

The proponents of this project are to be commended for advancing an innovative approach to balancing a multitude of conflicting ecological and water quality objectives. My best guess is that this project has a high likelihood of success. This report appears to be sufficient to select which among the possible alternatives deserve further analysis, but significant improvements in modeling and assessment must be made to accurately predict the outcomes possible from the final project. I specifically suggest that the project team be expanded to include members familiar with water quality issues in the Delta.

* Responses to comments are indicated as underlined text.

APPENDIX A

COMMENT LETTERS

Comments From California Bay-Delta Authority and Project Team Responses *

Flooded Island Feasibility Study Report Review Form
CALFED Bay-Delta Ecosystem Restoration Program
June 14, 2005

***DRAFT* Review Summary:**

Major points to address in Final Version of this report:

1. Clearly describe the objectives and expected outcomes of the study as written, which are different than the original study objectives, and document reasons for the changes in objectives

   <u>See Chapter 1 for additional language discussing changes to the original objectives.</u>

2. Clearly define "opportunities" and "constraints" and link directly back to the objectives.

   <u>See Chapter 2 for additional explanation of terms and summary table that illustrates how they link back to objectives.</u>

3. Clearly describe and justify how the "potential approaches" and "primary scenarios" were derived. Identify the criteria that were used to select the approaches and scenarios (and to dismiss others). The modeling to support the dismissal of Sherman Lake and Big Break as having effects on salinity **must** be documented. Expand on how criteria were used to complete the fatal flaw matrix. Point out if and how criteria or export/diversion locations were weighted in the analysis. Clearly identify the ecosystem restoration site selection criteria.

   <u>See Chapters 2 and 3 for additional explanation of terms, summary table, criteria, and preliminary modeling results/reasoning for dismissing Big Break and Sherman Island. Benefit-cost analysis in Chapter 4 has been revised to include weighting by diversion (volume). Chapter 3 provides additional explanation of ecosystem site selection criteria.</u>

4. Provide scientific citations for conclusive statements, or, if no or few citations for primary sources are available, qualify statements and acknowledge the uncertainty associated with them. **Explicitly** acknowledge assumptions, and identify where study outcomes are strongly influenced by assumptions.

   <u>Citations have been added throughout document.</u>

5. Be consistent in use of the term "water quality." Use more specific terms, e.g., "EC" or "salinity" rather than "water quality," when that is specifically what is meant. Define how "ecosystem water quality" is used in the report. Ensure that the terms "DOC" and "OC" are used accurately.

   <u>The terms "EC" and "Salinity" has been used where appropriate. The term "ecosystem water quality" could not be found. Clarification regarding the use of "DOC" and "OC" has been made.</u>

6. Clearly define residence time as used in this study and identify how it is different than the most common definition (see comments from reviewer #4 Scientific validity).

   <u>Definition of the term "residence time", as used in the report, has been provided in a discussion of residence time in Chapter 3.</u>

* Responses to comments are indicated as underlined text.

7. Remove or correct inaccurate statements about DOC and mercury. Clearly acknowledge the limitations of this study, **especially regarding DOC, mercury, and DO analyses**, and identify how those limitations will be addressed in the next study. (See especially comments from reviewers #4 and #8).

    <u>The Administrative Draft document acknowledged the high level of uncertainty associated with DOC, mercury, and DO. This has been emphasized further in the final document (see Chapters 2, 3 and 4) and any speculation has been qualified. Many of the comments made by reviewer #8 do not accurately portray what was presented in the draft report. See specific responses below.</u>

8. Improve recommendations for future work based on
    a. Identification of key limiting factors or uncertainties

        <u>See Chapters 2 and 5.</u>

    b. Identification of the limitations of the current analysis

        <u>See throughout document.</u>

    c. Testing of tools or field verification of their effectiveness at the appropriate scale

        <u>See Chapters 2 and 5. Chapter 2 identifies monitoring and adaptive management as a potential approach.</u>

    Identify future work necessary to inform determinations and development of a pilot study, and either identify clear criteria for selection of a pilot project and measurable objectives for a pilot project, or document how these criteria and objectives will be determined in the next study. (See more detail in comments from reviewers #1 and #4 Future work.)

        <u>See Chapter 5.</u>

9. Identify how future modeling efforts will address reviewers' water quality modeling comments, especially reviewers #4 and #8.

        <u>See Chapter 5.</u>

10. Identify how next steps will more thoroughly address beach stability, local residence time, Egeria and the invasive clam.

        <u>See Chapter 5.</u>

11. Incorporate specific comments of reviewers as much as possible.

        <u>See response to specific comments below.</u>

* Responses to comments are indicated as underlined text.

Individual Reviews:

Reviewer: Reviewer #1

Review:

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The objectives of the study (page 1-3) identify ecosystem values, water quality for water supply, and recreation as the focus of the study with some reference to flood control. For most studies the objectives would more explicitly point to an expected outcome. In this study, even though 'habitat diversification' is identified as the mechanisms of interest in objective 1, and marsh restoration is the focus on objective 2, the study really addresses the manipulation of tidal flows (rather than habitat diversification) as a means to alter water quality at various locations within the Delta. It seems that interests have changed since the inception of the effort, and this should be described and reflected in clear statements at the beginning which indicate the intent and expected outcome. Planning processes are frequently, almost preferably, iterative and the feasibility study would have more integrity and internal consistency if the objectives were reframed to focus on the things the study as written actually set out to do. It is also possible that some of the objectives as currently stated are in conflict with one another.

<u>The alternatives presented in Chapter 4 and pilot projects presented in Chapter 5 each include recommendations for water quality, ecosystem, and recreation related improvements. Where possible, these improvements were integrated within the general framework of "habitat diversity" (e.g., setback levees [water quality] with beaches [recreation] and marsh [ecosystem]) to achieve Objective 1.Clarification regarding project objectives have been added in Chapter 1. Tables are provided in Chapters 2 and 4 that link objectives to the alternatives.</u>

The opportunities and constraints assessment (it is not sufficiently quantitative or even structured to be considered an analysis) does not show clearly how it builds on the objectives, or how the component parts are linked. For instance, the list of 'conditions' identified on page 2-2 which provide the structure for the assessment are not founded in a technical discussion of Delta dynamics. The 'ecosystem' issues are really not issues but habitats or species. At this point in the document a conceptual model of how these 'conditions' interrelate within the flooded islands and their surrounding channels could help show why these have been identified.

<u>A discussion of Delta dynamics is provided in Chapter 1. A summary table that links Chapter 2 to objectives is provided at the end of Chapter 2. A conceptual model of the feasibility study is provided in Chapter 1.</u>

Within Chapter 2, opportunities, and constraints are identified with little definition of terms which allows for some confusion in the text. For instance, the issue regarding clam grazing on DOC is not presented clearly as an 'opportunity', and in many instances costs as assumed a priori to be a constraint (even when the purpose of most feasibility studies is actually to assess costs relative to the various benefits of action). This poor definition of terms and a failure in many cases to link the opportunities **directly** back to the objectives, is problematic. Similarly, it is not clear at all how the 'Potential Approaches' are derived or how they emerge, if at all, from the 'analysis' of the opportunities and constraints. Much more detail is required here and a justification for how these approaches were developed. In some instances, for example on 2.2-13 under DOC, the potential approaches are not actions at all, but lists of uncertainties. The section could be greatly improved by perhaps including sections on 'Critical Uncertainties' which are not the same as constraints, and applying a consistent approach to allocating issues into the categories.

<u>A summary table that links Chapter 2 to objectives is provided at the end of Chapter 2. The report acknowledges that there are conflicting conditions/issues and in certain cases opportunities may</u>

also be constraints. Additionally, in some cases, the identification of opportunities and constraints can be highly uncertain (e.g., DOC, methyl mercury, and *Egeria*); in these cases the recommended potential approaches included monitoring and adaptive management, not additional uncertainties.

The consideration of issues in the opportunities and constraints section is wide and the study does a good job at this point of identifying some of the issues that should be considered. In some cases the study stretches perhaps too far in considering the possible opportunities presented by the restoration potential. Lists of species that could benefit without a clear identification of the project features that would be necessary to produce the benefit doesn't inform the feasibility assessment well. The specific habitat requirements of the species (for example, those listed on page 2.3-2) must be identified for the project to take advantage of this 'opportunity'. Plans cannot be developed to address these needs or avoid the constraints unless cause-effect relationships are more clearly identified.

Much of the information in the feasibility study is based more detailed information provided in the Baseline Report. See Baseline Report for additional details on all resource topics. We disagree that the possible opportunities for the restoration potential was overstated. Restoration associated with new setback levees or restoration of Little Franks Tract may provide benefits as discussed in the document. Restoration of new and preservation of existing tidal marsh habitat is a desired outcome of CALFED (and other) efforts. The opportunities as presented in the document were clearly identified as potential benefits and were by no means definitive.

Without knowing the detail of the recovery plans for at-risk bat species, it also seems that the buildings and flood gates, fail to provide 'native habitat'. There is no need to stretch the potential benefits of this effort beyond those which may be supported by the habitats incorporated specifically in the design.

Regarding constructing gates that may be suitable roosting sites for bats, it was not stated that the project would provide "native habitat" but rather "suitable habitat". This has been demonstrated by the noted species use of constructed features for roosting. A citation has been added in the document.

However, despite this comprehensive approach some of the issues raised, such as MeHg and Corbicula, are not carried through in the rest of the study.

Uncertainties identified for MeHg and *Corbicula* are presented in Chapter 2. Because of the uncertainties associated with these two issues, it was deemed appropriate to limit discussion regarding potential impacts and/or benefits associated with these issues for each alternative. Additional discussion is provided in the Baseline Report.

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

Comments on many aspects of the approaches are provided in other sections (e.g., Alternatives Analysis). In general, the study is poorly supported by scientific citations and the validity of many of the statements made cannot be assessed. Some sections include abundant references, e.g., the Hg section, but in most others statements are not supported by studies. In many cases citations are to other consultant reports with few primary sources listed. Personal communication from experts is reasonable, but thresholds of elevation for vegetative growth (e.g., the depth tolerance of Egeria, or the growth limit for Tules) which substantially impact the feasibility outcomes in term of costs of fill must be supported by data or studies. There are so many unsupported assumptions in the study that could undermine the validity of the conclusions. It is essential that these assumptions are explicitly acknowledged and where they have major implications for the proposed features, the sensitivity of the study outcome to these assumptions must be assessed.

Scientific citations have been added to many statements throughout the document. Also, please see the Baseline Report for additional cited information. Regarding use of personal communications for Egeria, we relied heavily on Lars Anderson of USDA who is recognized for his considerable knowledge of this species.

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

Chapter 3 suggests that there will be a logical process used to formulate, evaluate and compare alternatives. This section also refers to another document – the 'Conceptual Alternatives Report' which was not provided as part of this review. It is possible that some of the fundamental questions on this section may be addressed in the report.

Early in Chapter 3 there is a major departure from the Objectives of the study. Rather than habitat diversification to address water quality, ecosystem restoration and recreation, the approach for water quality is the alteration of tidal hydrodynamics. This must be justified and explained.

Habitat diversification to address water quality was 1 of the 4 objectives. See Chapter 2 summary table for a complete linkage of objectives, issues, opportunities, constraints, and potential approaches. Chapter 3 has been reorganized to better present the selection of preliminary alternatives in relation to objectives. Also, see "Relationship to Objectives" for each of the alternatives in Chapter 4.

The 'Primary Scenarios' in table 3.1 are essentially a list of approaches that could be used to meet the project objectives. It is not clear how they were derived or why they are considered 'primary. Similarly, the 'most promising' tools are identified in Table 3.1 with no justification for why these are promising. No criteria are presented for the selection of the tools or the scenarios. Such criteria might include their successful use elsewhere in the Delta, in other tidal systems, proven by modeling but not in practice, etc.

The "primary scenarios" and "tools" were developed from the "potential approaches" outlined in Chapter 2, see summary table.

It is essential at this and other points in the study to show a clear line of reasoning that links the objectives to the opportunities to the approaches/strategies to the tools.

See Chapter 2 summary table.

The description of the tools and how they are conceived needs to be amplified. For instance, the habitat levees are apparently expected to withstand wind wave erosion. However the conceptual designs show central structures (either rock or wall) with beach and marsh in either side. It is not clear here how the beach or the marsh survive if there is indeed major exposure to wind waves, and why some type of offshore breakwater system around a central habitat/beach is not preferred to a central structure surrounded by unconsolidated material. Another example is the dismissal of certain types of proven avian habitat restoration as being too expensive while fill for tidal marshes (or even some kind of reverse liposuction using slurries) is kept on the table. This inconsistent, or at least poorly justified, selection of some tools over another does not serve the study well. Rather, clear criteria should be used and consistently applied to identify the preferred tools.

See Chapter 3 for additional explanation of criteria. Additional information is also provided in this chapter regarding sustainability and design of setback levees.

Similarly, more detail is needed to show how the site selection for the applications of tools, essentially the development of the alternatives, was determined. Sherman Lake and Big Break are dismissed as having no effect of water quality. The modeling to support this must be shown in the study. Also – if the objectives on page 1-3 were those really guiding the study these may not be dismissed if habitat diversification there could meet some of the eco and recreation objectives. Further exploration of what else could be considered at these sites may have identified alternatives with water quality benefits. For instance, if Sherman Lake provides a conduit for Sacramento water to enter the San Joaquin could that transfer of water not be enhanced by increasing the efficiency of water movement through the Lake, or Mulberry Slough, or associated channels, to provide WQ benefits? The study states that changes could only decrease the flow – this means too small a range of ‘changes’ have been considered. This project seems to focus too early on manipulation of salt rather than encompassing the mixing process and how it can be changed in a broader sense.

<u>This is thoroughly discussed in Chapter 3. Also see the Modeling Calibration Report and the Conceptual Alternative Report.</u>

The criteria used to identify the nine alternatives must be clearly stated.

The Fatal Flaw matrix is a good tool for preliminary screening of alternatives. However, the criteria used to complete the matrix must be clearer. Examples include:

- How long must EC be reduced by how much? The model may indicate decreases that are of little significance to water supply. If EC is already low enough, getting it lower shouldn’t always be a benefit.
- What exactly is the residence time criteria based on? The text indicates studies that show 20 days may not be a problem, but smaller times seems to be assessed negatively in the matrices.
- What makes any of the criteria fall into the FATAL category?
- How is uncertainty about the outcome in the matrix incorporated? The implication of the poor model calibration at SWP must be more fully explored here.
- Why cannot a change in EC be considered a Fatal Flaw?

The Fatal Flaw matrix approach should be expanded to include all of the possible outcomes of the alternatives. Screening should then be conducted on a full assessment of the impacts and benefits of the alternatives. At present, screening is conducted on WQ in isolation of the other factors.

<u>Reductions in EC were evaluated and compared from a relative standpoint without thresholds. Increased residence time was generally assessed negatively in the screening. See Chapter 3 for explanation of when criteria would fall into the “Fatal” category. The matrices are on evaluation device used in the study, see Chapter 3 for addressing uncertainty in the matrices. A change in EC is not considered a fatal flaw because optimization and/or refinement may result in significant change.</u>

The ecosystem restoration site selection criteria are very poorly defined. The categories used to rank options in Table 3.4-1 must be clearly identified and justified. What make a patch large medium or small – in relation to what? How is topographic diversity categorized? Perhaps most importantly how are all the criteria in the Table used to assess a final rank?

<u>See Chapter 3 for additional explanation. Also, see the Conceptual Alternative Report.</u>

For the selection of locations for the habitat levees, the same justification must be provided. Here it seems that the criteria are binary, all are weighted equally and ranking is based on how many criteria are met. This approach must be explained and justified – especially given the different approach used to tidal marsh restoration.

<u>See Chapter 3 for additional explanation.</u>

The selection of ‘representative’ alternatives from groups for further analysis based on a crude categorization of the tools used to achieve WQ benefits, seems to mask some important differences among the alternatives. Two of the nine, No FT and East Side open, include no tidal control structures. Given that one of the feasibility criteria to is be sustainability, the concept of including a detailed evaluation of at least one alternative that requires less O&M, future consumption of power, etc based on a non-operational approach to achieving the objectives would seem reasonable. East Side open has no obvious fatal flaws given that no case is made for a residence time of 12 days having fatal effects. The approach for the selection of the final alternatives does not appear to be based on any objective, quantitative metrics (or even ranks) related to the either the objectives or the stated evaluation criteria (see discussion of sustainability above). Why do all of the preferred alternatives include marsh creation at LFT? The evaluation provided here does not adequately support this as the only way to achieve marsh creation.

> No FT and East Side Open both had fatal flaws (fill material required and unacceptable for recreationists and Bethel Island residents, and blocked access to/from Bethel Island, respectively). The relatively confined nature of LFT gave it an advantage over several other locations. Also, see Chapter 3 for additional explanations.

The calculation of the BCI adds nothing to the analysis presented. The comparison of a percentage with a dollar value can be done directly without the need to multiply one by 100, and divide the other by 1,000,000. The exercise does not scale the values by a reference value – it merely makes the numbers fall within a certain range. In addition, the idea of averaging % change across four WQ locations (with different amounts of water extracted at each) as a measure of WQ benefit seems too simplistic.

> The BCI calculation was done solely to make reviewing the numbers easier on the reader. The BCI analysis has been revised to be weighted.

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

I cannot comment on the specifics of the WQ benefits evaluated or their geographic range. However, little explanation or justification is given for the time period and scale over which the analysis is conducted. The fact that only one of the structures is modeled with a variable operational regime clearly makes comparison among the WQ benefits of the alternatives inappropriate. Given that the team identify this as a problem, it seems curious that the study was completed in this manner. By acknowledging these limitations how can the study team justify using as quantitative BCI to compare alternatives where the calculations of % change are based on incomparable data?

> See Chapter 3 regarding time period used in the modeling. The study acknowledged limitations in the modeling and recommends that the refinement and optimization of each alternative be conducted.

5. **Water Quality Modeling.** For the water quality modeling component:
    a. Is the selected model appropriate for the level of analysis?
    b. Is the selected model appropriately calibrated?
    c. Are the modeling assumptions clearly identified, and are they appropriate?
    d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
    e. According to the study has the selected model been peer reviewed?

Beyond this reviewers expertise except where some modeling issues are covered in other comments.

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

Given the limitations of the analysis, inadequate application of criteria, and the apparent pre-selection of tools to be used to address the WQ objectives, the study does not provide an appropriate basis for recommending future work. The purpose of the proposed Pilot project is unclear. The study should point to future work based on:

- Identification of key limiting factors or uncertainties, and aspects of a pilot project which could be used to reduce these limits/challenges.

- Identification of the limitations of the current analysis. Presently the study points to the need for fisheries data without stating how the study could be improved by this.
- Testing of tools or field verification of their effectiveness at as small scale where appropriate (e.g., will beaches erode? will dendritic channels form? what is the recreational response to barriers across heavily traveled channels?).

    <u>Key uncertainties and potential approaches for dealing with them were identified in Chapter 2. See Chapter 5 for information on how the study would be improved and for an explanation regarding one of the purposes of the pilot projects (e.g., testing and field verification).</u>

The study does not identify clear criteria for the selection of a pilot project or measurable objectives for a pilot project.

<u>Development of criteria and measurable objectives for pilot projects is recommended as a next step.</u>

Prior to a pilot study a more objective evaluation of alternatives employing a wider range of approaches should be evaluated. The preferred group alternatives should be based on their representation of the approaches or their cost-effectiveness. Cost could be measured both in $ and in the amount of sediment required given that both are a limiting resource in the Delta. Each alternative should be seen as a series of increments (e.g., is the effect achieved in part by implementing only some of the tool, so many miles of levees, or so many acres of fill) and the costs in $$ and sediment terms compared to the outcomes relative to WQ, eco and recreational benefits. Pilot projects could then be used to begin implementation of the most effective increments, or those efficient components associated with great uncertainty.

<u>Recommendations for additional analysis, evaluation, and refinement of alternative and pilot projects were provided in the Administrative Draft. Total and unit costs were provided for importation of fill material (Chapter 4).</u>

7. **Additional Comments**.

I found several inconsistencies, repetitions, and misplaced tables within the document. It should be structured to be more concise in the text, and to show how the bulk of the document emerges from the study objectives.

<u>The problem statement and methodology sections (Chapter 1) were expanded significantly since production of the Administrative Draft. See Chapter 2 summary table and see “Relationship to Objectives” for each of the alternatives in Chapter 4.</u>

Reviewer: #2

Review:

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

I have been asked to review the Fisheries portion of this document, so all of my replies will focus on Fisheries and other relevant ecosystem processes. Overall, I feel like the authors did a good job in integrating the various components and explaining the progression from initial goals through preliminary alternatives and final recommendations. The definitions in the various sections are adequate, especially when dealing with more complex issues such as Mercury. The tables and figures throughout the document are especially helpful in grounding the reader with the wordings in the text and models.

One aspect I thought could be better explained in the Introduction is why the specific focus on Lower Sherman Lake, Big Break, and Franks Tract; I'm thinking specifically on the absence of Mildred Island. I assume this is because of the suitable location of the other three sites in regard to salinity trapping, as well as Mildred Island's location on the Middle River not being on as a direct path to the pumps. It would still be nice to mention it early in the report as a prominent flooded island, especially since later in the document it mentions that there is a lack of *Corbicula fluminea* at Mildred Island and that it would serve as a good study area.

See Chapters 1 and 3 for explanation of why the study areas were chosen and mention of Mildred Island (also noted in Chapter 2 regarding studying the difference associated with *Corbicula* presence).

Another discussion I felt lacking was a brief introduction on other Submerged Aquatic Vegetation (SAV) in the Delta besides *Egeria densa*, both non-indigenous and native. Although *Egeria* is definitely the most prominent and troublesome, there are some other species whose presence should be noted, so that the reader doesn't think that all SAV is bad. Specifically I'm thinking of the non-indigenous Parrot's Feather *Myriophyllum aquaticum*, and the natives Water Primrose *Ludwigia peploides* and Coontail *Ceratophyllum demersum*, and various types of Pondweed *Potamogeton* spp. amongst others. I think there is also an important role of Floating Aquatic Vegetation (FAV), notably the non-indigenous Water Hyacinth (*Eichhornia crassipes*) which has had very large abundances in the past and is currently controlled by the California Department of Boating and Waterways, and the native Pennywort *Hydrocotyle umbellata*.

Paragraphs on native SAV as well as FAV have been added in Chapter 2. A paragraph in the Opportunities section has also been added. Also, see Baseline Report for additional discussion.

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

I think the scientific validity of this report could be much improved by including more references in the scientific literature. This would allow readers to access other publications when they feel they need more information to understand what is being discussed. This would further give credence to the authors that they have done their homework and have a thorough understanding of the various topics. Although there is no need for a comprehensive listing of all relevant reports, a few key references would be beneficial, especially in regards to fish communities and SAV/FAV:

Additional citations have been added throughout document. Also see Baseline Report for additional information.

Brown, L. R. 2003. Will tidal wetland restoration enhance populations of native fishes? *in* L. R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1, Article 2.
http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2.
…especially the conceptual models on fish habitat use with and without SAV.

Grimaldo, L.F., W.Kimmerer, A.R. Stewart. 2004. Diet and carbon sources supporting fishes from open-water, edge and SAV habitats in restored freshwater wetlands of the San Francisco Estuary. Master thesis, San Francisco State University, San Francisco,
California.

Toft, J. D., C. A. Simenstad, J. R. Cordell, and L. F. Grimaldo. 2003. The effects of introduced water hyacinth on habitat structure, invertebrate assemblages, and fish diets. Estuaries 26:746-758.

I think the detail on the fish species that utilize flooded islands and could be affected is a bit light in detail. This may be intended, as it is stated that "A more detailed discussion of the specific fish species that may be affected by modifications to the flooded islands can be found in Section 4.7 of the Flooded Islands Feasibility Study Baseline Report." However, not having this other report, the description comes across as a bit vague, since this is a complex issue.

In the WEST FALSE RIVER GATE ALTERNATIVE (P. 4-8) it is stated that "San Joaquin River fall-run chinook salmon migrate through the Delta in the fall months, but operation of the barrier would not impede their migration because the barrier would be open at least half the time." This should be changed to what is stated in later discussions of striped bass and salmon, which states that operation of the barrier could be disruptive. Stating that the barrier will "not impede" is misleading, at the very least it should say "minimally" impede, as it has the potential to be disruptive if it blocks migration half the time.

It should be mentioned that the effect of the various barriers on *Egeria* growth could be similar for Water Hyacinth, by blocking flow this could also block in rafts of Hyacinth that wouldn't be flushed away and therefore stimulate more growth.

<u>See Baseline Report and additional detail provided in Chapters 2 and 3. See Chapter 4 for additional mention of water hyacinth.</u>

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

Yes, I think the development of the alternatives is well explained, and flows nicely from the preliminary alternatives into the preferred alternatives and final recommendations. Even though my focus was on evaluating the Fisheries component, I felt that all of the criteria were well represented in the decision process.

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

Water quality is out of my area of expertise, since my review is focused on Fisheries aspects. However, I found the water quality discussions to be very well organized. Evaluating it from my objective point of view, I found that I understood the various components and the train of thought of the authors.

5. **Water Quality Modeling.** For the water quality modeling component:
    a. Is the selected model appropriate for the level of analysis?
    b. Is the selected model appropriately calibrated?
    c. Are the modeling assumptions clearly identified, and are they appropriate?
    d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
    e. According to the study has the selected model been peer reviewed?

Again, this is out of my area of Fisheries expertise, but from an objective point of view I found the modeling component to be a useful technique for organizing and conveying the pros and cons of the various alternatives.

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

I would like to see more analysis of the effects of opening and closing the tide gates on flood/ebb tides, and during various seasons. It is mentioned in the report that additional modeling is necessary for this, which I agree is vital to the development of the project. It should not be ignored the effect that the blocking and low flows could have on fish as well as growth of *Egeria* and Water Hyacinth. The information I have is that DBW sprays for Hyacinth from July 1 to Oct 15. If barriers are closed before this, low flows may increase growth/limit flux of SAV/FAV.

<u>Water hyacinth has been added in Chapter 4.</u>

It is mentioned in the report that “Fisheries Field Data Collection and Investigations (with multiyear monitoring)” is recommended for refinement and optimization of alternatives. I think this is a necessary component for the success of the project, since there are so many unknowns with respect to native fish species. There are many questions as to the effects of the alternatives on *Egeria* and corresponding fish communities. I think the report would benefit greatly by incorporating a field-based research and monitoring program that can quantify such relationships throughout the development, implementation, and operation of the project.

7. **Additional Comments**.

Overall I think this is a comprehensive and well-organized report, and look forward to the continuing development of final recommendations and success of the project.

Reviewer: #3

Review:

1) **Comprehensiveness.** This study is essentially a scoping exercise in which a number of possible alternatives ("concepts") to meet water quality and other measures are explored. As the title implies, it assesses how a combination of engineering, ecosystem restoration and levee modifications to (three) flooded Delta islands will affect water quality at the export/diversion points in the south Delta, as well as effects on fish and other species of special interest and recreational values. In my opinion, the report is comprehensive in that it includes discussions of effects across the relevant impact categories of interest to CBDA, stakeholders and other interested parties. The report assesses such impacts for a broad set of alternative strategies and options. Given the complexities of the issues involved here, the report by necessity does treat superficially some of the nuances and intricacies which might be associated with the alternatives. However, this is a **feasibility** study, and the authors do a credible job of 1) explaining their criteria for evaluating likely effects, 2) presenting results in an easily accessible matrix of outcomes and costs and 3) noting what is missing or needs to be done in followup studies. The cost estimates used here for each alternative appear to be based on standard engineering accounting methods, and reflect costs for similar structures in the region. The costs are also conservative, in the sense that they include large upward adjustments for "contingencies" and other non-structural or non-project costs.
2) **Scientific Validity.** The processes used in the study appear to be common techniques for conducting a scoping exercise of this type. Specifically, the problem and empirical setting are identified, the list of policy options are enumerated and defined, and the effects of these on given state variables (e.g; water quality) are discussed. This is a feasibility study, it is not an attempt to perform original research. Instead, it uses common assumptions, insights from experts, and some modeling results from a water quality model to develop likely outcomes and costs. In my opinion, given the context of the study, the exercise is "scientifically valid".
3) **Alternatives Development and Analysis.** As noted above, the methods used here appear to be appropriate for the objectives of this study. I am not capable of judging the validity of all aspects of the conditions and assumptions (engineering and otherwise) embedded in the various analyses performed here but the report is transparent in terms of procedures, including strengths and weaknesses. I found the presentation of results to be easy to follow and the use of the matrix and associated fatal flaw analysis to be helpful. The validity of the findings (e.g. changes in EC at various points in the Delta) is a function of the water quality model, but to the extent that any model limitations are consistent across each alternative, one expects that the relative changes in basic water quality measures assigned to each option will be unbiased.
4) **Water Quality.** The primary measure discussed in the results is water quality in terms of EC at export or diversion points. This is not my area of expertise but I assume that such a variable is an acceptable proxy for drinking water quality. The report also discusses other water quality measures, such as DOC, which I assume also affects drinking water quality. The benefits of the alternatives are evaluated using an index number approach, where each alternative is rated in terms of changes in physical water quality (here EC). One possible extension of this analysis would be to translate these physical measures into some economic measure of benefits (say, reduced water treatment costs) associated with each water quality improvement. Also, as the authors note, there is no quantification (physical or economic) of non-market benefits associated with recreational values, endangered species or ecosystem services. This should be pursued to get a fuller sense of the consequences of the alternatives as the list of feasible options is explored in subsequent studies.

   <u>This suggestion will be considered for future phases/studies.</u>

5) **Water Quality Modeling.** I am not a hydrologist and can not comment on the validity of the model(s). However, as noted above, the model results are the basic output of this exercise and are used to determine which of the options pass the feasibility tests imposed here. Thus, the model(s) need scrutiny. I assume these are probabilistic models, so some discussion of the confidence intervals and uncertainties is warranted. I am not aware of whether these have been subjected to peer review.

* Responses to comments are indicated as underlined text.

However, I do note that much of the material used in this report is drawn from other reports, in which more detail is available.

The Calibration Report provides documentation on the formulation and performance of the hydrodynamic and water quality model utilized for this study. The model is not probabilistic. The model calibration report provides a significant representation of the accuracy of the model. However, during the pre-feasibility phase of this project, no attempt was made to provide formal uncertainty estimates for the predictions of salinity improvements at the export locations. Based on the model calibration, uncertainties are expected to be on the order of 10 to 15%, however, the next phase of the project should include more formal analysis of both model sensitivity and uncertainty.

6) **Future Work.** The study does propose the next steps in this process. As I understand it, the report will go before the CBDA and decisions will be made regarding which, if any, of these options gets pursued. The follow-up studies will need to address the options in more detail; the report contains a useful list of shortcomings of the preliminary analyses, which are candidate items for inclusion in followup studies. I was pleased to see the recommendation to consider sea level rise in the next stage of studies. I would also suggest that the study consider effects of levee stability related to earthquakes and flooding (see comment below).

See Chapter 2 regarding potential opportunities under flooding, earthquake, and levee failure scenarios.

Final Comment: This report is coming out at a time of increasing interest in levee stability and the role of the Delta islands in meeting CBDA goals. As you may be aware, a recent report by Mount and Twiss of the ISB, building on a DWR report by Torres et al., explores the probability of multiple levee failures due to earthquakes and flooding. While the Mount and Twiss report looks at the entire levee system, it has implications for the more focused effort evaluated in this study, in that levee failures elsewhere are likely to affect the outcomes of these more localized Delta measures. Also, as you are no doubt aware, DWR is beginning a two year Delta Risk Management Study (DRMS) to understand the role and consequences of the levees (and their possible failure) on the performance of CALFED operations. This issue of levee integrity and the Delta was a topic of considerable attention at the ISB meeting last month (May 10-11). Speaking only for myself, I believe the Delta levee situation is a major economic and policy issue that needs attention. Thus, I am pleased to see these various studies and analyses underway to address the long term challenges of dealing with the levees and the Delta.

Reviewer: #4

Review:

My background is in hydrodynamics and hydrodynamic and water quality modeling. Since, I do not have a broad enough background to answer all questions asked on this review form, I have focused my review on hydrodynamics and modeling.

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

Several desired outcomes are identified clearly. Several relevant issues are discussed in varying levels of detail, but I do not know the "full range" of relevant issues. More discussion regarding water quality analyses is provided in the response to question 4.

The most detailed analyses presented in the report are salinity analyses. The scope of the salinity analyses is probably appropriate for a feasibility analysis but is limited in several ways

- Only direct and immediate effects of alternatives are evaluated. Long-term effects of the alternatives are not considered in the salinity analysis.
    - All analysis was done with existing morphology. However, the proposed construction will alter circulation patters and sediment transport and, therefore, lead to geomorphic change. The longer-term effect of the proposed alternatives, including resulting geomorphic change, is not evaluated.
    - Similarly, sea level rise and climate change (change in timing and magnitude of flow events) are not considered in the simulations.
    - Additional restoration or levee failures could change the effects of the alternatives.
    - Scenarios for spread of Egeria are not considered in the salinity modeling
- Operation of proposed gates is not optimized.
- Beach stability is not discussed in the report. Is there an expectation that the beaches will be stable? If not, is the maintenance of the beaches included in the estimated budgets?

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

The numerical modeling approach used in the study may be adequate to address salinity issues. The RMA2 model has a long history of application in the Delta and was calibrated against a large set of data. Several assumptions and limitations of the model are outlined but model uncertainty is not discussed in adequate detail (see comments under question 5).

A substantial shortcoming of the report is limited reference of scientific literature and the relatively large number of "personal communications" cited. Whenever possible, statements of relevant knowledge or observations should be accompanied with citations of peer-reviewed literature. Much relevant literature has recently been synthesized by Kimmerer (2005) in San Francisco Estuary and Watershed Science.

<u>Additional citations have been added throughout the document.</u>

Several assertions are made in the report without explanation or citation of relevant literature. For example "large scale DO changes in Franks Tract would be unlikely" is stated without explanation.

<u>These types of assertions have generally been qualified throughout the document.</u>

The algae production model discussed on page 3-50 appears to be quite limited and may be inaccurate, particularly because it does not account for grazing.

<u>The model does account for grazing, see additional language provided in Chapter 3.</u>

The discussion of the residence time analysis is limited. Given that there are multiple definitions of residence time that are used in practice, both the definition and approach should be carefully documented. I found a definition in the Alternatives Modeling Report Draft by RMA. This definition should also be included in the Feasibility Study Report by EDAW. The definition by RMA is substantially different than the most common definition (e.g., Dronkers and Zimmerman, 1982) and may lead to smaller estimates of residence time than residence time according to the most common definition/approach.

<u>A complete definition of residence time, as used in the report, is provided in Chapter 3.</u>

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating, and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

The methods for evaluating and comparing preliminary alternatives were quite clearly documented. Several relevant evaluation criteria were selected though many more evaluation criteria could be taken into consideration. For example, I think that stronger consideration should be given to alternatives that provide operational flexibility, and can be implemented as pilot projects at reasonable expense. Similarly, options with less scientific uncertainty in water quality and other effects should be given more weight.

<u>This suggestion will be considered in future phases of the study.</u>

A key limitation of the comparison of alternatives was the lack of optimization of gate operation in most alternatives.

<u>Agreed, this limitation was noted in the report and will be addressed in future phases of the study.</u>

The benefit analysis was not clear but apparently weighted each export/diversion location equally. This does not seem appropriate.

<u>The Final Report includes weighted benefit-cost analysis.</u>

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

I can not judge the adequacy or appropriateness of the evaluation overall but it seemed uneven in level of detail of the water quality analyses. Relative to the detailed salinity modeling that was conducted the DO and DOC analyses seem to be based largely on professional opinion with little quantitative analysis. Given the apparent lack of quantitative analysis, some statements imply a surprising degree of confidence (e.g., "Although residence times would increase..., it would not be to a level to cause noxious algal blooms...")

<u>Some statements have been qualified throughout the document. Additional analysis of DOC is recommended for future phases.</u>

The discussion of mercury was also much less substantial than discussion of EC/salinity. The concept of the "reactive mercury pool" was not explained in adequate detail and expected effects of different alternatives on the "reactive mercury pool" are not discussed.

<u>Additional analysis of mercury is recommended for future phases. Also, see the Baseline Report for additional information on mercury.</u>

As stated previously in my comments, the time period/scale of analysis is implicitly the period directly following implementation of an alternative. Potential longer term changes resulting from the implementation of alternatives, such as geomorphic change, or independent of the project, such as sea level rise, are not considered in the analysis. This is probably appropriate for a feasibility analysis, but, given the great importance and expense of the proposed alternatives, further analysis would be useful in an EIR-EIS. The rationale for the chosen simulation period appears to be primarily that it is the model calibration period and that it is during summer conditions when water quality concerns are present.

<u>Agreed, this suggestion will be considered in future phase of the study and would be addressed in an EIR/EIS.</u>

Only a portion of the future modeling needs is clearly identified. The report does mention that a broader range of hydrologic conditions may be considered in later phases and that the simulations should optimize gate operation. Additional modeling needs are described in my comments under question 6.

<u>Additional clarity has been provided in Chapter 5.</u>

5. **Water Quality Modeling.** For the water quality modeling component:
   a. Is the selected model appropriate for the level of analysis?
   b. Is the selected model appropriately calibrated?
   c. Are the modeling assumptions clearly identified, and are they appropriate?
   d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
   e. According to the study has the selected model been peer reviewed?

The numerical modeling approach used to address salinity and flood stage issues is appropriate but limited. The assumptions and uncertainties associated with the model are not adequately discussed. Before construction of pilot projects a substantial uncertainty/sensitivity analysis should be performed to better understand the uncertainty associated with the model's predictions.

<u>Agreed, this has been included as a recommendation in Chapter 5.</u>

Because the validity of the modeling approach depends strongly on the degree of model calibration, I reviewed the RMA Delta Model Calibration Draft. Clearly a large amount of work has gone into model development for this complex system and the degree of comparison to stage, flow and salinity observations is generally high. However, discussion regarding model assumptions, limitations, and uncertainty is limited. I have the following substantial comments on the model calibration document:

- The model calibration report suggests that the model accurately represents stage, flow and salinity throughout most of the Delta during summer conditions. However, it should give greater emphasis to the prediction of salinity at export/diversion facilities. For example, a table could compare the predicted monthly averaged EC (used as the metric of salinity reductions) to the observed monthly averaged EC for each month during the simulation.

- The document should discuss limitations of depth-averaged modeling, which may be substantial in Suisun Bay and significant in the western Delta. Not representing vertical gradients in salinity may limit the model's predictive ability. For existing conditions, "three-dimensional processes" can be parameterized to some extent by dispersion coefficients. Table 3-1 suggested that various tuning coefficients were tuned in multiple regions to improve the calibration. However, for project conditions or flow conditions different than the conditions present during model calibration, mixing parameters may no longer adequately represent "three-dimensional processes" because the location, strength, and tidal phasing of stratification will be different under these different conditions.
- Potential errors introduced in the salinity boundary condition should be discussed in detail. On Page 4-1, the document states that "the average of surface and bottom EC was used." This suggests at least two substantial errors:
    - The average salinity of top and bottom observations does not accurately represent depth-averaged salinity.
    - Depth-averaged salinity at the salinity station does not accurately represent cross-sectional average salinity.
- The method of handling wetting and drying should be discussed in more detail. It is not clear from the discussion if the method conserves water volume or if velocities are estimated realistically in shallow regions.
- On Figure 4-6, Mildred Island is not shown as a flooded island. Is it treated as a flooded island in the RMA model? If not, this assumption seems inappropriate and is not discussed in the text. If it is treated as a flooded island, all relevant figures should reflect this fact.
- Page 7-1 states that "EC is treated as a conservative constituent for model simulation." However, EC is not conservative; therefore this assumption will lead to some error. Is this error significant? Salinity is conservative, why is it not used in the model?
- Page 2-1 states that "the RMA2 model is capable of representing the influence of a baroclinic distribution..." It should be noted that RMA2 can only represent depth-averaged baroclinic pressure gradients. Because it is a depth-averaged model, it can not account for the vertical variability in baroclinic pressure gradients that leads to gravitational circulation. This should be noted for clarity.
- The representation of vegetation in the simulations is reflected in the Manning's n coefficients in Table 3-1, but not discussed in any detail.
- It is not correct to refer to the Smagorinsky sub-grid scale mixing approach as a "turbulence closure" (e.g., page 3-6 and 10-6). This approach estimates sub-grid scale mixing based on resolved (grid scale) velocity gradients. Because the resolved velocities are Reynolds-averaged velocities (not turbulent velocities), the sub-grid scale mixing estimated by the Smagorinsky approach represents mixing due to small scale Reynolds-averaged velocities. The resulting mixing coefficients are generally larger than turbulent mixing coefficients which represent the effects of turbulent time and spatial scale motions.

<u>See Calibration Report and Alternative Modeling Report (RMA 2005). A table can be added to the calibration report comparing predicted monthly averaged EC with Observed Monthly Averaged EC. The model uses a depth-averaged approximation in the western Delta and Suisun Bay where significant vertical gradients in salinity are often present. Vertical gradients in salinity may lead to three dimensional circulation patterns that will not be represented by a two-dimensional depth-averaged model. Instead, the three dimensional processes are approximated by two-dimensional mixing parameters. The calibration results show that the model was able to very accurately transport salinity from the tidal boundary at Martinez, through Suisun Bay, to Jersey Point and False River for the 2002 period simulated. In other modeling work using the full RMA Bay Delta model with the salinity boundary applied at the Golden Gate, the two-dimensional representation has been shown work well during most conditions. The approximation has the most difficulty during the transient recovery of salinity following a large net delta outflow. In this case the model salinity recovers more slowly than the real system. Generally the model catches up to the observed salinity within one to two weeks</u>

following a large storm event. There is some concern that calibrated mixing coefficients would not be appropriate if the system configuration was changed significantly. Modeling of the Jones Tract levee failure has shown that the model performs adequately given a large change in tidal prism. In the modeling of the Feasibility Study alternatives, there were no changes proposed that would strongly affect the flows through Suisun Bay, and, therefore, the calibration of mixing coefficients will probably not be affected. This issue could be explored further during a future phase of the project.

The model network used for the alternative analysis approximated Mildred Island as off-channel storage of the one-dimensional elements surrounding the island. A test simulation was performed with Mildred Island represented with two-dimensional depth – averaged elements, but there was no significant improvement in accuracy of the model with regard to overall flows or salinity transport in the Delta.

Additional discussion of EC will be added to the calibration report.

Additional discussion of the approximation of the baroclinic pressure gradient and Smagorinski method will be added to the calibration report.

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

The report does clearly identify pilot projects. However, it does not discuss monitoring the effects of pilot projects or how the success of pilot projects will be evaluated.

Developing monitoring and success criteria have been identified as a recommendation for future phases.

Additional modeling would reduce uncertainties and improve confidence in the modeling approach

- Sensitivity analyses could provide insight to model uncertainty.
- Applying the model to a wet and/or an extremely dry (drought) period, without altering any model parameters, would provide insight to the predictive ability of the model. If the model does not predict salinity accurately during a wet period, this suggests that model parameters apply only for the conditions of the model calibration period and would decrease confidence in the model's ability to predict project conditions.
- Supplemental application of a three-dimensional model, perhaps over a smaller model domain, would provide insight to the importance of salinity and temperature stratification. Such a small scale study of Mildred Island is in progress by Seungjin Beuk of UC Berkeley. Three-dimensional simulations will be increasingly important for many likely future scenarios, including sea level rise and levee failure scenarios, in which the salinity and stratification are likely to intrude further into the Delta.
- The RMA2 model, in conjunction with a three-dimensional model, should be applied to various future scenarios that include geomorphic change scenarios, sea level rise scenarios, climate change scenarios and restoration/levee failure scenarios.

The reviewer makes several clear suggestions for future work which should be considered if time and funding allow.

7. **Additional Comments**.

Editorial Comment:

- Redundant terminology is used repeatedly in parts of the report. For example:
  - "Stage elevation" should be changed to "stage"
  - "Salinity concentration" should be changed to "salinity"
  - Most instances of "salt content" should be changed to "salinity"

- “Erosion caused by scouring” should be changed to “scouring”

Suggested changes have been made throughout the document.

Reviewer: #5

Review:

1. **Comprehensiveness**.

Overall the report does an excellent job in stating the goals and objectives and then identifying the methods in achieving those goals. It is not clear why the report makes no distinction between the water quality, and volume, requirements of drinking water versus agricultural irrigation water. While weighting the difference drinking water and irrigation water would be subjective, it would present a point of view that could then be debated. As it is left in the report, it leaves the reader with complete autonomy in making his own judgment. The report identifies the rationalization of the other goals well enough to support future debate by stakeholders. The report will lack a little clarity for some readers in its mixed use of S.I. and U.S. Customary units. On page 4-45 the report refers to having performed the analysis for the year 2000 while earlier stating that the modeling was performed for the year 2002. There is no clear reference provided for the report's identification of riparian, tidal marsh, and riparian elevations of <-1-ft, -1 to +4-ft, and >+4-ft, respectively. I am not aware that there is a general agreement on these values and a clarification would be helpful. The same clarification would be helpful on the report's identification of shallow water habitat as being below 3-meters – one of the report's uses of S.I. units.

<u>The benefit-cost analysis has been revised to be weighted for each diversion point. The use of units has been made consistent. Modeling was performed for the year 2002, this typographical error has been corrected throughout the report. Citations have been provided for habitat elevations. All measurements have been changed to Imperial for consistency throughout the document.</u>

I might suggest further clarification of the following passages:

Page 2.3-11 – what are planktonic fish eggs and larvae?

<u>This statement has been clarified in the final report.</u>

Page 4-22 – three gates would be operated in tandem – while the meaning is clear, most would argue that only two items can be operated in tandem.

<u>The 3rd gate was never included in the modeling (i.e., modeled as open), and has been removed from the alternative.</u>

Page 4-30 – It is possible; however, the entrainment reduction benefits associated with this barrier operation could be offset by increase entrainment from Middle River. – It is not clear what is possible nor to what entrainment the sentence refers. Only by thoroughly reading the Alternatives report and the calibration study did this become clear.

<u>This statement has been clarified in the final report.</u>

Page 4-37 – escalated from 1985 values by a factor of 174% - there will be some who will wonder if you have increased 1985 values by a factor of 1.74 or have increased them by 174%.

<u>This statement has been clarified in the final report.</u>

Page 4-39 – Each ... value was then numerically averaged – many readers will not be able to decipher your meaning from the chart. Obviously you cannot average a single value, but are averaging the averaged-diversion values for each alternative.

<u>This statement has been clarified in the final report.</u>

* Responses to comments are indicated as underlined text.

General – the report uses a mixture of singular and plural uses of the word ‘data’. To this reader the word is always plural.

<u>All uses of the word ‘data’ have been changed to plural in the final report.</u>

2. **Scientific Validity.**

All methodology was well presented and documented except for the cost benefit analysis. It is clearly arguable that the straight percentage weighting for each diversion location and alternative should be weighted by the benefit of the water quality improvement to the use as well as by the volume of each individual use. Even the report acknowledges this shortcoming without justifying it in any way. An attempt at water quality benefit and volume weighting will serve as a point of discussion and provide a common method of adjustment for the discussion.

<u>The benefit-cost analysis has been revised to be weighted for each diversion point.</u>

3. **Alternatives Development and Analysis.**

While the weighting methods are a matter of discussion as to the relative merits by various stakeholders, the methodology was appropriate and well supported. Alternative that were eliminated were properly documented and the level of uncertainty was qualified were it was not possible to quantify.

4. **Water Quality.**

By necessity, water quality is qualified rather than quantified in the study. Water quality is quantified using electrical conductance (EC) as a surrogate for all water quality and other water quality parameters were qualified with the best known understanding of how they too would be affected. The study examines a rather low-flow water year which would provide conservative results and best quantify a bad case scenario, even if not the worst case. For a feasibility study this approach is satisfactory although a final study would require a longer time period and range of flow conditions. The study acknowledges that both a longer period and additional water quality parameters should be explicitly modeled for a final study alternative to be reached.

5. **Water Quality Modeling.**

The RMA2 hydrodynamic model and the RMA11 water quality model are quite appropriate for the hydrodynamic issues of the study domain. The codes of these models and numerous applications of the models have been well analyzed and reviewed in the literature; while no specific peer review has been made of this model application. Ideally one would like to have separate data sets with which to calibrate the model and then verify the model's performance. Realistically, there is rarely enough data to even properly calibrate the model. In this case there were additional data collected in 2002 to supplement the ongoing data collection efforts of various agencies. These data allowed an adequate calibration of the model that revealed a few minor flaws for which there is simply not enough additional data to pursue corrections. The model is then used to examine the results of applying the alternatives to the model domain. The alternative simulations are then analyzed with consideration given to the minor flaws in the calibration. The uncertainties of the calibration and the application are well documented.

6. **Future Work**.

The study does a good job in identifying the next steps required for the implementation of pilot projects either implemented in part or on a larger scale. Clearly for future work it is necessary to continue field measurements so that this model or another model can be further calibrated and then verified. The data required for this work include stage, flow, and additional bathymetry refinement. Small scale demonstration projects, undertaken during the ongoing collection of data and model refinement, would serve to validate the future larger-scale restoration. There are still a number of chemistry questions to be answered before one can expect to properly model DOC or Hg effects. Additional work may be needed to even qualify the value of different forms of DOC.

<u>Chapter 5 of the final report includes recommendations to better understand DOC and Hg effects.</u>

7. **Additional Comments**.

At some point it is going to necessary to consider individual projects within the Delta as a whole rather than by themselves. Clearly something along the lines of the proposed Through Delta Facility could easily overshadow any individual project and render it unnecessary or contra-indicated.

Reviewer: #6

Review:

Comprehensiveness. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The report clearly outlines the objectives and evaluates the alternatives to meet those objectives. The process through which the alternatives were developed is clear except that it was not entirely explicit (to me) why alternatives were not explored for Big Break and Lower Sherman Lake.

Explanation of the dismissal of Big Break and Lower Sherman Lake is provided in the final report.

The opportunities to address the issues are for the most part well covered. However, on page 2.2-9, authors should mention that phytoplankton growth is generally light limited in the Delta (one reason habitat manipulations are thought to potentially improve production) and that grazing by clams exerts a strong control on phytoplankton productivity in the Delta-- which is another important consideration when manipulating habitats to improve productivity (this is mentioned but not in this regard here).

These comments have been incorporated into the final report.

What is meant by "ecosystem water quality" is not entirely clear to me from the report.

We could not find this term in the document.

Scientific Validity. Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

For the evaluation criteria, the definition of "residence time" is needed. Moreover, the use of water velocities (if possible) to evaluate potential effects on Egeria might be beneficial. For example, in the North Levee and Two Gates Alternative Ex.4.3-4, authors estimate a decrease in Egeria, but the effect of decreased velocities (which could increase Egeria) where north and western openings are closed (although mentioned) are not thoroughly evaluated or discussed.

A definition of residence time is provided in Chapter 3. Additional analysis on egeria and water velocities id recommended in Chapter 5 of the final report.

On p. 3-50: the description of assumptions about phytoplankton growth are vague... I realize this model and these assumptions were just used to get a conservative estimate of maximum residence time to prevent noxious algal blooms, but I have listed comments below that should be considered and caution the extrapolation of these results without incorporating other factors (like light attenuation and grazing).

Authors should mention that in the Delta, phytoplankton growth is generally limited by light availability. Nutrients are rarely limiting (Jassby et al. 2002). Specific questions and comments about this paragraph are as follows:
1)What is meant by "if light and temperature are just right" Do the authors mean if light and temperature are *optimal* for phytoplankton growth? Does this take into account light attenuation values characteristic of the site?

Clarification is provided in the final report.

2) What is the death rate attributed to? Is this supposed to mean loss to flushing (or transport from the system?) or loss to respiration or a combination? This should be clarified.

Clarification is provided in the final report.

3) Benthic grazing can be extremely important in habitats colonized by invasive clams and this fact should be stressed--especially because clams are abundant in Franks Tract.

Additional information is provided in the final report.

4)In the Delta, sinking phytoplankton are probably more prone to light limitation in stratified water columns than to limitation by cooler temperatures.

This comment has been included in the report.

Jassby AD, Cloern JE, and Cole BE. 2002. Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem.

Alternatives Development and Analysis. Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

I answer yes to all of the above except that a more thorough use of water velocity data could be beneficial (see answer to "Scientific Validity" above). Also, it seems some uncertainties discussed in the text might not be reflected in the screening criteria matrix (for example uncertainty discussed in final paragraph on 4-12 not reflected in matrix 4.3-4).

Additional analysis on egeria and water velocities id recommended in Chapter 5 and additional discussion on criteria is provided in the final report.

Water Quality. Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

The geographical coverage of salinity changes could be broader. For example, authors mention concern of salinity of Agriculture return water, so it would be useful to know salinity changes NE of Franks Tract near Ag intakes (I didn't see this in the evaluation). Also, if salinity changes are substantial within Franks Tract, that would be useful information because it could have ecological implications (e.g., for *Egeria* or *Corbicula* growth inhibition--which is mentioned in "Opportunities").

This comment will be considered in future phases of the study.

Water Quality Modeling. For the water quality modeling component:
Is the selected model appropriate for the level of analysis?
Is the selected model appropriately calibrated?
I am not a modeler so I can't answer these questions adequately.

Are the modeling assumptions clearly identified, and are they appropriate?
Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce

uncertainties presented? **The assumptions seem clear to me and uncertainties are acknowledged. Actions to reduce uncertainties are mentioned (like using a broader range of hydrologic conditions).**
According to the study has the selected model been peer reviewed?
I did not get this impression from the report

Future Work. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?
Refinement of the alternatives would benefit from the following steps (in addition to those mentioned in the report):
1) Exploring more detailed effects of flow regime on Egeria
2) Employing data on invasive clam distributions and abundance to refine alternatives
3) Evaluating more regional implications of flow regime changes on water quality

<u>All of these comments will be considered for future phases of the study.</u>

Additional Comments.

Exhibit 1-1: A legend would be helpful. Also a marker for the Delta on the state of California would be beneficial for anyone not familiar with the area.

<u>A legend has been provided in the final report.</u>

Great illustrations alternatives and levee constructions-very helpful!

Reviewer: #7

Review:

1. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The "desired outcomes" (project objectives and feasibility study objectives) are clearly identified individually, separate from one another, as though compiled from multiple stakeholder and technical advisory groups. The project study purpose, and list of project objectives is quite complete. There is some inherent ambiguity in describing the underlying nature of the proposed interventions for the flooded islands: the study includes some habitat restoration components, but it is not overall an "ecosystem restoration", and does not claim to be. The purpose seems to be enhancement of beneficial uses (habitat, recreation, water quality, etc.) within the constraints of the stated problems of flooded subsided delta islands. It seems that the generic term "rehabilitation" applies to this approach. The integration of desired individual outcomes for the project's "site concepts", articulated as coherent, multi-faceted alternatives, is less clear. The design features of alternatives are not entirely comprehensive in that they do not stress <u>integration</u> of specific engineered design approaches to tidal marsh, recreation, flood control, SAV control, etc. They seem to function as a suite of co-located semi-autonomous projects, related as in a specific geographic area master plan. The alternatives appear to be composites of subordinate project designs, rather than integrated wholes.

<u>Additional information regarding integrating project objectives with alternatives is provided in Chapter 4.</u>

The level of explanation is somewhat uneven. There seems to be relatively more discussion of uncertainties, problem statements, and hypotheses (e.g., subjects such as DOC, methylmercury transformation, fish ecology, nonnative SAV ecology) than applications of expertise and demonstrated technology in the design of alternatives to address them. For example, there is an ample scientific literature (including gray literature) on tidal marsh restoration, vegetative stabilization of shorelines or dredge material islands, but there was very little discussion of design approaches, materials, methods from other regions applied to the Delta oligohaline, microtidal, relatively sediment-starved environment. I did not find the level of "site concept" discussion of tidal marsh restoration technology and conceptual designs to be as specific or detailed as the explanations of uncertainties about SAV ecology, fish behavior, methylmercury, etc. For example, despite the repeated desired outcome for "dentritic channels", there was no discussion about how they could be feasibly formed, or even whether they would form. This is remarkable since all alternatives propose creation of 420 acres of tidal marsh in Little Frank's Tract, with no variation in methods or materials, and almost no explanation beyond the thumbnail design criterion of filling (with what? Sand? Mud?) to -0.5 NGVD (p. 4-17). There was also little or no discussion of re-engineered shoreline configuration design, relationships between restored tidal marsh and amenity beaches, and possible design alternatives for setback levees (surprisingly limited to rock or concrete, with limited explanation). The level of detail for bioengineering (soft shoreline stabilization) techniques was good, as was tidegate hydrologic design, but these contrasted with the relatively cursory treatment of tidal marsh and riparian woodland/scrub restoration methods.

I don't think the discussion suffered from lack of (or weak) definitions. The rigor of discussion was more often limited by repetition of defined terms like "dendritic tidal channels" without delving into what they mean in an applied restoration/rehabilitation conceptual design.

<u>Additional information regarding construction of tidal marsh and riparian woodland has been added to Chapter 2. If restoration features of this project move forward, detailed restoration plans will be developed that describe methodologies for implementation.</u>

2. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

The uncertainties were very thoroughly dealt with, and they may have been emphasized so much that they called into question whether there was sufficient understanding of the problems, and corrective technologies, to justify intervention at all. The emphasis on complex factors affecting outcomes (for example, non-native fish and SAV relationships) was perhaps excessive, leading to perplexing statements such as:

Overall, there is no definitive information on the relative weight of opportunities and constraints associated with the creation of additional shallow water habitat or increased habitat diversity within the flooded islands, with or without colonization by SAV, which would clearly demonstrate the population level benefits to the native fish assemblage" (p. 2-23, Draft Report)

On the face of it, this unqualified conclusion undermines justification and basic feasibility of one of the principal objectives of the project, diversification of subtidal and intertidal aquatic habitat (1-3), an opportunity defined on p. 2-21. The scientific validity of stated opportunities and constraints seem to pass each other by. This is echoed, for example, in discussion of *Egeria* invasion problems stated on pp. 2-22 to 2-23 (almost all scenarios worsen uncontrollable *Egeria,* with no effective control method identified). This apparent pessimism stands in marked and unexplained contrast with the approach to methylmercury uncertainties on p. 2-11. There, the complexity of ecological processes governing the problem is interpreted to provide "some level of assurance" that intervention will not make methylmercury problems worse. Comparable "assurance" is not the interpretation for SAV and fish interaction complexity, even though there is a solid case that matters may be worse regardless of alternatives selected. More editorial consistency of scientific judgment would be appropriate here.

> <u>Not all alternatives definitively worsen egeria, it tends to be rather speculative for this study. Comparable levels of assurance cannot be assessed for all conditions/issues because the levels of uncertainties can vary. Additional analysis is recommended in Chapter 5 of the final report to address critical uncertainties.</u>

Given some of the fundamental uncertainties identified, evaluation criteria and design rationales should stress practical affirmative aims for decision-making and design, working around uncertainties now as much as possible, rather than trying to resolve them with future studies/adaptive management. In other words, stress what is known or judged likely to work, based on either local experience or comparable experience in other regions. In the case of the quoted sentence above (2-23), what would "clearly demonstrate the population level benefits" mean? How "clear" or certain do the lead agencies need to be in order to make a decision about what to do for fish? In an ecological engineering context, there is an inevitable (low) limit to predictability and theoretical adequacy, and a natural role for professional skill, judgment and expert opinion to pick up where scientific certainty leaves off.

Some assumptions of the study seem to be scientifically validated by repetition more than reference to scientific literature. There is a widespread assumption in the report that high current velocities are a threshold limiting physical factor for *Egeria* establishment. It is not at all clear, however, whether this apparent relationship is based on a restriction of *Egeria* colonization by mobile substrates and high shear under high current velocities, mechanical injury or inhibition of *Egeria* growth under high velocity currents, or erosion of established colonies. If the effect of high current velocities on *Egeria* is merely on frequency of successful founder colonies, the interpretation of a velocity threshold for maintaining *Egeria*-free subtidal habitat may be in error. Progressive clonal expansion from well-anchored, continuous stands may spread from sheltered sites to progressively higher-energy sites. This does indeed appear to be consistent with patterns of subtidal SAV bed progradation in the aerial photos of Frank's Tract.

> <u>For detailed information regarding egeria, please see the Baseline Report. Regarding threshold limiting physical factors for this species, elevation and energy and substrate stability would all affect egeria. Exposed horizon and wave action decreases the presence of egeria. Egeria can live in depths down to 12 to 14 feet and up to 3 to 4 feet as measured at high tide, but generally only down to 9 feet in Franks Tract.</u>

3. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

The alternatives development seemed to focus on engineering levee and water control gates, emphasizing effects on water quality (salinity), with ecosystem and recreational elements as accessories or amenities. Any landscape-level considerations of alternatives design and function appear to be driven by the levee and gate engineering. The alternatives flow directly from the "toolkit" with little evidence of landscape ecology or large-scale geomorphic design. The overall harmony of main effects and side-effects of the large-scale designs were not well explained in terms of basic project objectives in "discussion of benefits and impacts". For example, the opportunities and constraints discussion emphasized substantial public interest in open water navigation and sport fisheries (2-31), and the ecological problems of *Egeria*. The alternatives emphasized closing of levee breaches and construction of tidegates, while acknowledging that increased sheltering of subtidal beds by closed levees and gates would likely increase *Egeria* spread, and restrict navigation. How were these factors weighted? Were these "overriding project goals" (p. 1-4) weighted equally, or do some override others? Were the constructed recreational amenities (mooring and docking areas, launches, beaches) and emergent wetland construction (habitat levees, filled restored marsh) considered to be internal "mitigation" or counterbalancing factors for the major side-effects on navigation and SAV impacts from channel engineering? There seems to be omission of an executive rationale for trade-offs, priorities, or overriding considerations, given the even-handed treatment of opportunities and constraints earlier in the document. An explicit, plain-language comparison of alternatives, with values and judgments of priorities made clear, would be appropriate.

<u>See Chapter 2 for a summary table linking opportunities and constraints to objectives and Chapter 4 for a discussion regarding relationship between alternatives and objectives.</u>

It was surprising to find that no alternatives addressed one of the major constraints identified for flooded islands: excessive wind-wave energy due to unbroken fetch and excessive water depth. The only design approach for mitigation of excess wave energy was construction of habitat levees, and only "habitat" levees with cores of concrete or rock (no alternatives with habitat levees emphasizing soft stabilization of low-angle slope earthen materials). The concept of breaking up flooded islands with marsh islands (or archipelagos of islands) was not considered, and "avian habitat islands" were rejected (p. 3-6) with surprisingly little analysis or discussion; the main reasons given were vulnerability to erosion and large fill requirements. These potentially important habitats seem to be rejected with too little reason. These were not compared, however, with total cost and fill requirements for hard-core habitat levees. Alternative marsh or upland island designs with varying degrees of shoreline armoring were not considered, even though rock and concrete cores were standard features of "habitat levees" in all alternatives. This appeared to be an engineering bias towards a favored design approach for structural habitat levees (wave barriers) over widely dispersed marsh islands and upland islands (wave attenuation, fetch reduction). Trade-offs between relative wildlife and habitat diversity benefits of marsh islands, terrestrial islets, and habitat levees (or variable combinations) would have been worthy of discussion.

<u>See Chapter 3 for additional discussion on engineering, stability, and sustainability.</u>

An alternative, intermediate design blending marsh islands and habitat levee concepts would be to combine deepwater channel dredging with side-cast submerged "levees" acting as shallow subtidal to intertidal platforms for tule marsh, within flooded islands. This would generate a skeletal channel-marsh structure that would serve navigation/recreation interests in low-*Egeria* deepwater channels, provide emergent marsh/open water edge habitat, and impede open-water wave propagation (increase bed roughness). This local cut/fill approach would require less net fill import than island construction. It would be no more or less artificial than islands or habitat levees.

<u>The reviewer's suggestion will be considered in future phases.</u>

4. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

Water quality is outside my expertise, but it was evident that the introduction used somewhat exaggerated non-technical terminology and imagery to describe current water quality issues in the delta: on page 1-1, the Problem Statement referred to salinity as a function of "high-salt content *ocean water* with daily tidal action", in a sentence beginning with "Salinity concentrations *within* the Delta" (emphasis added). Similar references to "sea water intrusion" and "a *wide range* of salinity" (p. 1-2) are found elsewhere (p. 2-3). The oligohaline (not "saline") estuarine nature of the delta wetlands, and complex estuarine salinity gradients are not well described by this language. No context of natural salinity variation (marine, lower estuary, upper estuary) or regulatory salinity thresholds (standards, drinking water) is presented along with this introduction, making the reference lopsided. Salinity values stated on p. 2-25 are questionable. While this misleading ambiguity may have been unintentional, for non-technical decision makers who may review only the introduction and recommendations, this introductory discussion is disorienting. Seawater intrusion probably *should* be discussed in terms of marine transgression and accelerated sea level rise over a 50 to 100 year planning framework. There is surprisingly no discussion of sea level rise and salinity intrusion (marine/estuarine transgression) in the introduction, constraints discussions, or alternatives designs. This is quite anomalous for coastal planning in California (or any other coastal locality).

5. **Water Quality Modeling.** For the water quality modeling component:
    a. Is the selected model appropriate for the level of analysis?
    b. Is the selected model appropriately calibrated?
    c. Are the modeling assumptions clearly identified, and are they appropriate?
    d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
    e. According to the study has the selected model been peer reviewed?

(Water quality modeling is outside my expertise)

6. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

The outline of pilot project actions (5.3.3) does not include any design concept information comparable to that given for temporary rock barriers, pocket beaches, and levee/gate designs. No variation in methods or materials for creation of marsh or riparian woodland is identified, or for establishment of dendritic or simple tidal channels. Variation in methods and materials would be expected for adaptive management approaches to habitat restoration. Despite the predictable increase in SAV with greater sheltering due to levee reconstruction (closing), there appears to be no identification of monitoring of *Egeria* spread response to pilot project construction. This would be informative for deciding whether to carry over the pilot study to full implementation.

7. **Additional Comments**. See below.

Specific comments

Page (draft) **subject** **comment**

2-7	DOC	Text explains that phytoplankton productivity is "necessary to support a Delta food web of diverse and desirable species", and also "believed to be an important source form of reactive DOC potentially leading to THM formation". Despite discussion of "potential approaches", there is no clear guiding principle for alternative designs regarding context for increasing or decreasing phytoplankton productivity; ambivalent opportunities and constraints discussion dangles rather than guides. Deferred study (adaptive management) does not inform current alternatives design and outcome (p. 3-6). Discussion of operable gates is provided in Chapter 3 as potential means for controlling residence time and flushing phytoplankton to the west Delta. Potential ecological response is complex and largely unknown, therefore, adaptive management recommendation is provided.
2-10	meHg	Reference to important "recent findings" (not available in standard reviews from last several years) should have references in literature cited. Personal communication referenced is provided.
2-12 to 2-14	meHg	Given complexity of meHg, and need for working hypotheses that consistently and actively guide design principles for comparison of alternatives, there is a need to summarize best professional judgment or working assumptions for site concept designs. There is a gap between this discussion and alternatives design; they seem to bypass. Recommendations are provided in Chapter 5 of the final report for additional analyses.
2-15	Tidal marsh	Note recent taxonomic nomenclatural changes for *Scirpus*, in which subgenera are elevated to genus rank: "tules" are placed in *Schoenoplectus*, "bulrushes" are placed in *Bolboschoenus*. "Threesquare bulrush" is the common name of *S. americanus* (formerly *Scirpus olneyi*), not *B. robustus*. The common name for S. olneyi in the document has been corrected. Other comments noted, latin names conform to Jepson Manual and have not been changed in this document.
2-15 2-19	Tidal mudflat, Sand dredged materials	"Tidal mudflat" is discussed as a habitat conversion opportunity, but most of the available dredged material from the Delta, as I understand, is likely to be sandy or sand. Both mud (clay-silt) and sand have potentially valuable habitat restoration functions, but they differ, and are hardly equivalent. There construction traits contrast strongly. Mudflat is not really "equivalent unvegetated substrate" comparable with rootwads for most wildlife species; shorebirds do not forage or rest on rootwads (large woody debris). Dredged material located on Decker Island is silty sand. Anchored rootwads would not necessarily be a key habitat component but rather a means to provide a buffered backwater area to protect the mudflat from wave erosion and allow suspended material to settle out.
2-15 2-18	Large woody debris	I strongly agree that including large woody debris (snags, rootwads, logs "recycled" from felled large Eucalyptus) in wetland restoration designs would be highly appropriate and useful. The elimination of large woody debris sources in the delta is as ecologically significant as sediment starvation due to dams, in my opinion. The value of large

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		woody debris in the upper estuary habitat is probably as significant as it is in nontidal freshwater rivers. Standing boles (snags) prostrate large wood (rootwads, logs), and woody debris jams, should be considered in levee and tidal freshwater marsh designs. <u>An opportunity paragraph has been added in Chapter 2 that discusses including woody debris in restoration design.</u>
2-16	Mosquito production	Rather than focus only on mosquito predators, physical factors that limit survivorship of mosquito larvae (e.g. pond fetch, wind-wave turbulence, tidal range, tidal circulation) should be discussed with equal or greater emphasis in context of tidal marsh. <u>The reviewer's suggestion will be considered in future phases.</u>
2-17	Tidal marsh	Technical variations in established biotechnical stabilization designs should be considered as adaptive management for "scaling up" successful techniques to sites the size of Frank's Tract, with due attention to economy of scale. "Setback levees" and "habitat levees" described in other DWR contexts do not have engineered or armored cores, so this increased design cost should be critically explained and justified, with lower-cost alternatives considered. <u>The reviewer's suggestion will be considered in future phases.</u>
2-18	Trees, levee stability	References to scientific/technical literature are needed for tree/levee instability "belief". Critical evaluation of the potential destabilizing effect of isolated trees on levees, compared with continuous established canopy and root networks of riparian woodland, would be quite helpful in this context. <u>This statement has been removed in the final report.</u>
2-20	Fish habitat	Again, complexities of ambivalent or ambiguous hypotheses are not reconciled as a "best professional judgment" or "working hypothesis" for habitat design guidelines, or even leading alternative guidance principles in "potential approaches". Are uncertainties overstated, or is the science really this muddled? Is there enough science to make decisions or set up focused tests of restoration hypotheses? An explicit statement would be helpful. "Potential approaches" (2-24) discussion is anomalously simplified, vague, general, and brief compared to the technical preambles about uncertainties; it talks around a conclusion. But this is the section that really should integrate and guide alternatives design for fish. Lack of consistent guidance <u>See Chapter 2 for additional discussion and summary table on potential approaches.</u>
2-24	Egeria/SAV	"Algal mats" probably refer to epiphytic filamentous algae. "Mats" are planar filamentous algal masses, floating or bed-attached. Waterfowl (diving ducks) probably do not utilize sediments over the entire depth range of *Egeria* (foraging in top meter/2 m?). Salinity tolerance stated of "10-12 ppm for few days" is perhaps ppt, because even nonhalophytes would not physiologically "feel" 12 ppm. <u>Algal mats discussion has been clarified. Typographical error regarding ppm change to ppt has been corrected.</u>
2-25 see also 2-28, 3-2, 4-4	Egeria/SAV sand	Much more discussion is needed for statement about Egeria establishment limitation on unconsolidated substrate (sand) and restoration design potential. This implies a major design feature for the "toolkit", where SAV control is otherwise very pessimistic. Integration of several features mentioned in different parts of the document (deepwater dredged channels for recreational boating, placement of sandy dredged materials for habitat) should be integrated to design experimental innovative channel habitats to test resistance to SAV invasion. Bed substrate mobility in deep channels backfilled with sand (banks defined by constructed marsh or habitat levees)

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		should be considered as a multi-function anti-*Egeria* design. Use of subtidal sand deposition (as opposed to dredging) to smother Egeria beds should be considered, since the resulting mobile substrate would be potentially less conducive to recolonization, compared with consolidated substrates in high-energy subtidal environments. Integrate navigation and restoration discussions. Recommendations are included in Chapter 5 of the final report to address Egeria issues/effects.
2-25 2-26	Egeria/SAV Native SAV	While it is true that "native SAV cannot be achieved by hydrodynamic means alone", neither approaches nor alternatives discuss possible experimental methods of establishing native SAV (in constructed "backwater" conditions) to pre-empt (exclusion by manipulated invasion sequence) SAV space. An opportunity paragraph for restoring native SAV has been added in Chapter 2.
2-26 2-27	Egeria/SAV Corbicula	Relationship between *Corbicula* and *Egeria* should be discussed. Does *Egeria* preclude *Corbicula* beds? Does *Egeria* removal increase *Corbicula*? Which is worse in what context? Is there any evidence that Mildred Island is actually resistant to *Corbicula* invasion because of environmental attributes, or is the invasion pattern stochastic, circumstantial? Research effort should be commensurate with potential for environmental effects. Discussion on relationship between Egeria and Corbicula has been provided in the final report.
2-28 2-29	Navigation Tidal wetland restoration	The discussion of opportunities for boating access "reaches" toward innovative tidal marsh restoration and landscape-level wetland design, but this is not reflected in corresponding tidal marsh discussion sections. The clear potential for integration of navigation and tidal wetland restoration should be developed, and reflected in alternatives designs. Integration of navigation and tidal marsh restoration was not envisioned in this study primarily due to the damage to tidal marsh caused by boat wakes. Navigation and other boating/recreational improvements are discussed separately.
2-30	Navigation dredging	Why would costly "repeated channel dredging" be necessary in apparently sediment-starved, static bed of Frank's Tract? Suspended sediment driven shoaling is only one form of shoaling. Another means of shoaling relates to the potential for wind-wave re-suspension and resultant deposition. While the jury is still out on the matter of the former means of deposition, the latter method is certainly of high potential to occur at FT. More specifically, considering the shallow nature of FT coupled with the frequency of almost daily high wind events, the potential for wind/-wave driven re-suspension is believed to be quite high. Such potential leads us to believe that dredged channels would likely silt-in from such deposition.
2-31	Open water Sport fishing	Discussion should consider spatial segregation of "striper hole" habitat (open water sport fishery areas) and native-priority fisheries and wetland habitat. Some areas could be dedicated to recreational amenities (mooring, beaches, open water navigable sport fishery areas, high maintenance), while others emphasize wetland, channel habitat for native species to minimize overall conflicts in priorities (see "strategic location" approach for Egeria on p. 2-34). The approach of "alternative recreation experiences" of tidal marsh is simply not credible for the existing public interest in sport fisheries and recreational boating (see p. 2-31), and seems disingenuous. For the most part, the alternatives did address recreation and habitat

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		amenities separately. We were merely suggesting that there may be a further opportunity for those with a slightly different interest to enjoy tidal marsh either in a passive or active way. We don't believe this statement is disingenuous.
2-38 3-29	Erosion, sand beach, Beach orientation	Erosion of beaches is not just a function of wave energy; it is strongly influenced by shoreline configuration and nearshore slope. Indented "pocket" shorelines can trap sand so alongshore transport is precluded, and nearshore slope can be flattened enough so that offshore (deepwater) losses are minimized. Low-energy beaches tend to become vegetated; open sand favored by recreation is maintained by periodic high energy erosion/accretion cycles. Beaches should also be considered as habitats (nesting, loafing); not all constructed beaches should be recreation-priority, or designed solely for recreation. Beaches should be considered in context of island habitats as well as recreation (pp. 3-5, 3-9) with integration or segregation of design concepts, as appropriate. Emergent sand landforms (emulating splay deposits) can be important restored habitats, transitional from marsh to riparian woodland and low dunes. We agree with the opinions expressed by the reviewer. The location and extent of the pocket beaches were determined with these in mind. We concur that beaches in low-energy areas will vegetate. For instance, the beaches along the west side of Franks Tract will tend to vegetate more so than the eastern pocket beaches because of the higher wave exposure experienced by the eastern beaches.
3-5 3-27, 5-6	Habitat levees	The description of habitat levees invokes the name applied by earlier DWR/USFWS design, but design drawings all feature costly structural (concrete/rock) components that are not discussed or justified in context of the text until p. 5-6, with no explanation. The need and purpose of rock/concrete walls is not clear, nor is the justification of this added feature over alternatives emphasizing low-angle slopes of earthen fill, and vegetative stabilization. The primary need for a "core" (be it rock or concrete) was to ensure the levees could perform their primary duty – diverting water flow. While it is true, perhaps one could use larger earthen fill structures, the resulting footprint would most likely be significantly larger and thus require the use of likewise significantly greater amounts of fill.
3-11	Residence time, algal bloom	Nutrient loading is a highly important factor in calibrating relationships between estuarine water residence time and algal blooms during summer. Comparing widely contrasting salinity and settings may generate excessive noise in data analysis. Comment noted, the authors acknowledge the complex nature of residence time and algal blooms. Discussion of the model was provided for preliminary screening and additional analysis is recommended.
3-23	Marsh size, perimeter (edge)	The relationship assumed for marsh area and "dendritic tidal marsh" needs critical review. The illustration (see all figures of Little Frank's Tract) of historic mature tidal sloughs formed in accreted sedge/tule peats is very misleading in the context of constructed freshwater tidal marsh habitat. There is, to my knowledge, no supporting evidence that placement of mineral sediment, especially sand, is amenable to formation of this type of channel system either in the Delta or anywhere in the Corps of Engineers national program of creating marsh island habitats with dredged materials. This illustration is not instructive without text explanation. The discussion should discuss whether it is known whether it is the channel habitat structure itself, or the marsh/open water edge structure, that is known to be associated

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		with specific ecological functions or benefits. If marsh/open water edge is a key variable, then other marsh restoration configurations should be considered, especially if they are more compatible with known constraints of marsh construction. Additional explanation of tidal marsh habitat is provided in the final report. The exhibits (4.3-1, 4.3-3, 4.3-5, & 4.3-7) that include Little Franks Tract are intended to be preliminary sketches of the potential area that could be converted to tidal marsh. They are not intended to be design or as-built drawings of the tidal marsh /slough network nor are they intended to depict historic tidal sloughs of Little Franks Tract. (Similar to the blue line that depicts the gates/barriers.) The material (likely from Decker Island) that may be used to create tidal marsh is silty-sand which is appropriate for creation of tidal marsh. Design details for restoration components would be contained in a separate document that provides specifics regarding proposed configuration, elevations, plant materials, to what degree natural colonization would be utilized, use of woody debris and other materials, sustainability, maintenance, and likely ecological functions and values.
3-30 and all "Discussion of Benefits and Impacts" , Section 4, Section 5	Summary; integration	A table or bullet list can be used effectively to summarize atoms of information, but these are not effective for actual integration of summarized discussion. Section 3.6 needs explicit explanation of the decisions and rationales for the framework of alternatives brought to full feasibility evaluation, and reasons for screening out others. Policy and value issues should be made explicit in integration discussions comparing alternatives, especially where major trade-offs are made. Additional explanation and discussion is provided in the final report.

Reviewer: #8

Review:

The subject report describes a series of projects that together have the potential to improve drinking water quality in the southern Delta, as well as address issues of aquatic habitat for native species in the western Delta.

Unfortunately, the quality and level of analysis, and modeling are insufficient to assess if the putative improvements will be realized.

This review is confined to drinking and environmental water quality aspects of the report, including, where appropriate, modeled aspects of water quality.

8. **Comprehensiveness**. Are the desired outcomes clearly identified and is the evaluation appropriate to those outcomes? (How did they get from A to B, is this clearly explained and justified?) Is the full range of relevant drinking water quality, agricultural water quality, ecosystem water quality, fish migration, habitat value, recreational fishing, and recreational boating opportunities explored by the study? If not, what is missing? Are the definitions of these resources adequate?

The report is significantly lacking in several key areas related to water quality, as described below. The justification for alternative selection frequently cannot be interpreted in the current report because the underlying assumptions are invalid. The water quality assessment should be repeated using the correct assumptions, adequate model performance verification, and an expanded suite of evaluation criteria.

9. **Scientific Validity.** Has the study used adequate approaches (experimental, empirical, and numerical) to address the identified issues? Are these approaches adequately documented, e.g., were the assumptions outlined and appropriate, and were the uncertainties dealt with appropriately, especially in terms of the evaluation criteria? How could the approaches be improved?

The scientific basis used for evaluation of prospective improvements in two important aspects of water quality, DOC and mercury, are deeply flawed and should be corrected, and the analysis repeated with the correct information.

Organic Carbon:
Dissolved organic carbon (DOC) presents problems for drinking water utilities because it may form regulated byproducts (THMs and other disinfection byproducts [DBPs]) change disinfectant demand, or clog membranes. The report correctly describes DOC as arising from a variety of processes and representing a myriad of chemical types, and possessing important qualitative differences that affect DBP formation. However, the authors do not appear to be aware of the recent research in the Delta that has investigated the sources and composition of the DOC with respect to DBP formation.

The analysis in the report incorrectly asserts that phytoplankton are the dominant source of DOC in the Delta. This is probably the result of confusion between the sources of OC (usually particulate organic carbon) that supply essential nutritive material to the aquatic food web, and DOC, which has lower direct nutritive benefits to the food web. The text of the report often inappropriately interchanges the terms OC and DOC. For example, the report, without attribution, states that “River sources of organic carbon appear to dominate in the winter, whereas biological processes (phytoplankton growth) in the Delta appear to dominate in the spring and summer (p2.2-8).” It further states that “Phytoplankton are also believed to be an important source form of reactive DOC potentially leading to THM formation (p2.2-9).” Neither of these statements is correct with regard to DOC.

<u>The report DOES NOT assert that phytoplankton are the dominant source of DOC in the Delta. The terms DOC and OC are not interchanged. The word ‘important’ has been removed from the statement “Phytoplankton are also believed to be an important source</u>

form of reactive DOC potentially leading to THM formation" and citations are provided for both statements in the final report.

Extrapolating based on the flawed assumption that DOC arises from phytoplankton, the report surprisingly concludes that invasive clam species will help ameliorate changes in DOC production by consuming phytoplankton: "Consequently, although invasive clam species are generally acknowledged to be undesirable,…..their influence through algal consumption provides some assurance that the potential strategies *would not likely alter THM formation potential* in water supplies because *any increased algae production would be consumed by clams* (2.2-12; emphasis by reviewer). This assertion is misinformed, irresponsible, and disingenuous. If this is the basis for modeled changes in DOC, the model analysis is deeply flawed. This appears to be the case (p3-35). More recent models of phytoplankton production are available for the Delta that explicitly include issues of light limitation (3-50).

The statement regarding clams has been removed in the final report. Changes in DOC were never modeled. A discussion on light limitation has been included in the final report.

Contrary to assertions in this report, recent analyses of historic data indicates the majority of DOC added in the Delta is added in the winter and spring, with smaller amounts added in the summer and fall. Most active researchers in the field agree that the dominant sources of DOC in the Delta are Delta peat island drains and wetlands, comprising 50% of the DOC added in the winter, and 0-25% added in other seasons. The amount added by each of these sources is still under investigation, but recent evidence indicates wetlands are a much larger contributor than previously thought. Phytoplankton, often light limited in the Delta, are thought to be a less important source of DOC from a variety of lines of evidence.

The report DOES NOT assert that the majority of DOC added in the Delta is in the summer and fall. The commentor's statement that "Phytoplankton, often light limited in the Delta, are thought to be a less important source of DOC from a variety of lines of evidence" needs to be qualified from the standpoint of drinking water or food web as phytoplankton have been documented to be important to overall ecosystem productivity (citations provided in the final report). Additional discussion on phytoplankton being light limited has been added to the final report.

Several presentations at recent CALFED Science conferences calculated the DOC export from various land uses and from Delta phytoplankton production. They found that per unit area, wetlands export 10-20 times the amount of DOC than from peat island agriculture or phytoplankton. Since agriculture occupies a large fraction of the area of the Delta, it can be expected to contribute a much larger fraction of DOC than algae. The report discounts the potential effects of wetlands by saying: "How wetlands function affect DOC production, timing, and interactive influences of hydrodynamics on the transport of DOC from wetlands is not well understood (2.2-13)." Although on the surface, it appears that the extent and position of the wetland restorations contemplated in Frank's Tract will not have a significant impact on DOC, the effect should be accurately assessed using the hydrodynamic model and reasonable assumptions for DOC export from tidal wetlands.

The report acknowledges wetlands, peat island agriculture drainage, and phytoplankton as sources of DOC. The report DOES NOT discount the potential effects of wetlands, it simply states acknowledges the complexities and uncertainties associated with production, timing, and interactive influences of hydrodynamics on the transport of DOC from wetlands. Recommendations for additional analyses of DOC are provided in Chapter 5 of the final report.

Mercury:

The statement suggesting "clean inorganic sediments" support high concentrations of bioavailable Hg whereas anoxic organic sediments have high sulfate reduction rates results in wetland restoration not greatly affecting MeHg production is a spurious conclusion (p2.2-14). Clean inorganic sediments tend to have pore waters that are significantly lower in total Hg compared to organic sediment pore waters. The relative

proportion of "bioavailable Hg" is usually higher in inorganic sediments because organics can bind large quantities of Hg2+ into organic complexes. However, organic sediment pore waters almost always have much higher concentrations of all forms of Hg compared to inorganic sediment pore waters. Furthermore, current studies are investigating the role of organic matter in mobilizing sediment bound Hg into the water column and thus the food chain.

<u>The report DOES NOT make CONCLUSIONS regarding the above referenced statement (clean inorganic sediments), it simply acknowledges that this is one more important piece of the puzzle that needs to be considered. A discussion on pore water is included in the final report.</u>

The contention that there are assurances that changes in hydrodynamics may not substantially alter existing MeHg interactions is irresponsible as it presumes knowledge not yet available (p2.2-16). That the central Delta has very low biota concentrations of Hg despite the area seemingly being a prime location for Hg methylation is an area of active investigation. It could be just one variable that has created this anomaly and any change in management could tip the balance and have a significant impact on methylation in the area.

<u>The report states that MeHg interactions MAY not be substantially altered and acknowledges the uncertainties. Additional analysis is recommended in Chapter 5 of the final report.</u>

It is wise to propose using "clean" sediments to reduce the potential effects of construction activities using Hg-laden sediments (p2.2-16). However, it is erroneous to suggest that clean fill could "eliminate" MeHg formation. MeHg tends to be about 0.1% - 10% of total Hg depending on environmental conditions, regardless of total Hg concentrations. Therefore it is wise to reduce the total Hg and thus reduce MeHg concentrations, but environmental conditions will govern the percentage of MeHg over as much as 2 orders of magnitude. It is important to remember that no soil is Hg free and there will always be plenty total Hg to produce MeHg. Using cleaner fill will reduce the effects compared to Hg-laden dredge but cannot be said to "enhance" the food web over current conditions.

<u>The report DOES NOT state that clean fill will eliminate MeHg formation, it does use the words 'reduce' and 'minimize'.</u>

The work of Mark Marvin-DiPasquale on reactive Hg in sediments is very important (p2.2-18) but so is speciation in overlying waters, particularly photolytic effects. Also salinity/organic matter influences and water column mixing effects on photoeffects and reactive Hg cycling are very poorly understood in this environment.

<u>Additional discussion on photoeffects is provided in the final report.</u>

There is a range of sulfate levels that is optimal for Hg methylation (p2.2-17), and altering the salt distribution in the Delta may help reduce sulfate levels below that range but that is not known. Redox in soils with fluctuating water tables may govern sulfate levels in the interior delta more than imports.

<u>The report uses the words 'may' and 'potential'.</u>

In conclusion, the authors have failed to incorporate even some extremely fundamental aspects of DOC and Hg geochemistry into their water quality analysis, and have not incorporated basic knowledge of geochemical processes in the Delta into their analysis and modeling. Accurate assessment and modeling of the effects of hydrodynamic and restoration changes should be conducted using correct geochemical assumptions.

<u>The reviewer seems to suggest that the modeling of DOC and mercury is flawed, when in fact there was no modeling of these constituents as part of the current phase of this study.</u>

10. **Alternatives Development and Analysis.** Are the methods for formulating, evaluating and comparing preliminary alternatives (for achieving water quality, ecosystem and recreation objectives) clearly

documented and appropriate? Were appropriate evaluation criteria selected for identifying preferred alternatives? Were the criteria weighted appropriately during the evaluation? Is the rationale for discarding specific alternatives explicitly documented? Were uncertainties considered appropriately in the evaluation of alternatives?

As suggested elsewhere, the criteria for analysis should be broadened to include several parameters:

a) The distribution of residence time in model grid points rather than bulk residence time should be used for evaluation as this impacts the geochemical and ecological benefits.

b) Source and specific drinking water parameters should be included in the modeling and analysis; most importantly SUVA (defined elsewhere) and bromide.

c) Uncertainties are minimized or not addressed adequately in the current report. Model errors in replicating EC in the central Delta, while acknowledged, are not incorporated in a systematic way in the evaluation of alternatives. Uncertainties should be assessed, propagated, and reported in graphical presentation of results.

<u>Modeling of residence time did consider the variation of residence time across Franks Tract, see Alternative Modeling Report. The reviewer's suggestions have been included as recommendations and shall be considered in future phases.</u>

11. **Water Quality.** Is the full range of water quality benefits adequately identified and evaluated? Is the geographical coverage of the evaluation appropriate? Does the evaluation consider the existing regulatory constraints appropriately? Does the water quality assessment consider the appropriate time period and time scale? Does the study explain how the assessed time period compares to the historic record and the rationale behind using the chosen time period? Does the study clearly indicate future modeling needs and are they appropriate?

Discussed in next section.

12. **Water Quality Modeling.** For the water quality modeling component:
    a. Is the selected model appropriate for the level of analysis?
    b. Is the selected model appropriately calibrated?
    c. Are the modeling assumptions clearly identified, and are they appropriate?
    d. Are the modeling uncertainties and their ramifications explicitly identified? Are methods/actions to reduce uncertainties presented?
    e. According to the study has the selected model been peer reviewed?

The modeling efforts described in this report, while commendable, are incompletely calibrated, do not accurately represent the current flow system, and make assessments based on flawed assumptions.

Modeling efforts should be modified in several significant ways:

a) The modeled time period should extend over several years, and should include successive dry and wet years, and transitions from successive dry years to a wet year.

<u>Agreed, these recommendations are included in Chapter 5.</u>

b) The model should extend over the entire year. Even though the focus of the project is salinity improvements at drinking water intakes, and there is lower salinity in the winter, there is a possibility that the high DOC levels in winter may occur at the same time as elevated salinity. Higher DOC and salinity together (even if salinity is only modestly higher than current winter levels) have the potential to increase DBP formation in these waters.

<u>Agreed, these recommendations are included in Chapter 5.</u>

c) The geographic extent of the model should be expanded to include the effects on the eastern Delta because the modified flowpaths described in the report have the potential of exacerbating dissolved oxygen problems in the SJR deep water ship channel.

This suggestion will be considered in future phases.

d) **The model should be run for the decade or more where EC, DOC, SUVA are available at several interior Delta stations and the results compared to actual values. The model should be able to replicate variability in these important parameters under historic conditions to be suitable for scenario testing. The error should be included in the uncertainty assessment.**

Agreed, these recommendations are/have been included in Chapter 5 of the final report.

e) **I suggest that the model explicitly include model assessment of changes in bromide (the most problematic drinking water issue for salinity) and Specific Ultra Violet Absorbance (SUVA). SUVA provides a rough estimate of the sources of DOC, particularly from peat islands, and there is a long time series available for model calibration.**

Recommendations for additional analysis have been included in Chapter 5 of the final report.

f) **In addition to bulk residence time, the frequency distribution of residence time in model grid elements should be used to compare alternatives. The model should be modified to provide this output. This is necessary because a rapid flow across, for example, the eastern edge of Frank's Tract may result in a short bulk residence time for the Tract, but residence time in some areas may increase significantly, altering the geochemistry and habitat quality of those areas.**

See Model Calibration and Alternatives Modeling Report.

g) **As described above, model assumptions are deeply flawed and must be corrected.**

Recommendations for additional analysis have been included in Chapter 5 of the final report.

h) **Model results for Big Break and Sherman Lake that incorporate potential restoration scenarios should be presented to assist in assessing the potential ecological and geochemical effects.**

An explanation of dismissal of Big Break and Lower Sherman Lake is provided in the final report.

13. **Future Work**. Does the Feasibility Study identify adequate next steps for alternatives refinement and optimization and identification of pilot project(s)? What additional research or modeling would you recommend to fill in gaps or reduce uncertainties? Which activities should be undertaken first?

Many suggestions for improvement of current and future work are presented elsewhere. One significant deficiency of the current analysis, and one that should be incorporated in to future analyses is the potential to alter sediment fluxes of constituents of concern both during and following restoration. It is self-evident that dredging and sediment placement will alter the DOC and Hg dynamics. However, one aspect not considered is the geochemical effects of sediment compaction. While the high likelihood of sediment compaction is noted in the report, it does not appear to be considered that this process will eject pore fluids into the overlying water. Ejected pore fluids will likely be enriched in DOC and Hg because of the organic matrix and reducing conditions. This ejection has the possibility of lasting for several years until the sediments are fully compacted.

A discussion of sediment compaction and pore water effects has been included in the final report.

14. **Additional Comments**.

The proponents of this project are to be commended for advancing an innovative approach to balancing a multitude of conflicting ecological and water quality objectives. My best guess is that this project has a high likelihood of success. This report appears to be sufficient to select which among the possible alternatives deserve further analysis, but significant improvements in modeling and assessment must be made to accurately predict the outcomes possible from the final project. I specifically suggest that the project team be expanded to include members familiar with water quality issues in the Delta.

State Water Contractors

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June 22, 2005

Mr. Don Kurosaka
Project Manager
Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001

Dear Mr. Kurosaka:

The State Water Contractors (SWC) is an organization representing 27 public water agencies operating within California who contract with the California Department of Water Resources (DWR) for water supplies from the State Water Project (SWP). The SWP supply delivered through the Sacramento-San Joaquin Delta (Delta) constitutes a significant portion of the supplies available to SWC members. As a result, the SWC is very interested in matters affecting the reliability and quality of water supplies in the Delta.

The SWC has been pleased to follow the development of the Flooded Island Feasibility Study. Our representatives have had the opportunity to participate in a number of your planning meetings, and we appreciate the broad-based approach DWR has taken to the Flooded Island Feasibility Study. The study encompasses water quality, ecosystem and recreational issues, while also focusing on the critical issue of salinity intrusion in the Franks Tract area and the resulting degradation of water quality at our export facilities in the south Delta. As was stated at the Public Hearing on the report on June 16 at Bethel Island, this study provides a good overview of initial conceptual alternatives for salinity reduction and other benefits. However, further in-depth work will be needed to address specific issues. We support this sequential approach, which is essential in order to find affordable and supportable solutions. The SWC requests that the report introduction be revised to acknowledge explicitly the very preliminary nature of this study.

We have particular concerns with the extremely high cost of the improvements shown in the Flooded Island Study, and believe much more affordable and implementable solutions are possible through a phased approach, which provides incremental benefits and the opportunity for adaptive management. From the work thus far, it is difficult to separate out and easily see water quality benefits and costs, although we believe such benefits and solutions can be developed from the information in the report. This is clearly needed to create a business case for investment by water stakeholders. We recommend development of a Pilot Project as the next step, which can be evaluated in real time to form the basis of a full-scale solution. We believe this approach is fully compatible with the work done thus far in the Flooded Island Feasibility Study.

We recognize further reconnaissance study is needed to develop a Pilot Project over the upcoming months. The State Water Contactors is prepared to work with you in this effort, which we believe to be in the interest of all. Thank you for considering these views and including them in the comment section of the report.

Sincerely yours,

Terry L. Erlewine
General Manager

STATE OF CALIFORNIA—THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, *Governor*

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June 20, 2005

Don Kurosaka
Department of Water Resources
1416 Ninth Street
Sacramento, CA 95814

Subject: Draft Feasibility Study Report for the Flooded Islands Project

Dear Mr. Kurosaka:

Thank you for sending the above named document dated June 2, 1005 to the Delta Protection Commission for review and comment. The Commission itself has not had the opportunity to review the feasibility study report, so these are staff comments only. These comments are however based on the Delta Protection Act of 1992 and the Commission's adopted Land Use and Resource Management Plan for the Primary Zone of the Delta.

The location of the three islands evaluated in the feasibility study report--Lower Sherman Island, Big Break, and Franks Tract--are located in the Primary Zone of the Delta. However, the Commission only has appeal authority over local government actions so Department of Water Resources (DWR) projects are exempt from the Commission's jurisdiction and these comments are advisory only. The Commission's concerns would focus on the project's compatibility with the Act and Plan and the impact of the proposed project on the resources of the Primary Zone.

The proposal is for a project included in CALFED's August 2000 Record of Decision (ROD) under Ecosystem Restoration (restore habitat and hydraulic needs on Franks Tract). The ROD had a more aggressive timeline--scope and feasibility by 2002 and implementation at the end of Stage I . As this is a ROD project, environmental review for the proposed project should tier from the programmatic environmental documents and should include mitigation measures included in the ROD. The ROD mitigation measures (7.7) for Recreation state "Incorporate project level recreation improvements and enhancements".

The feasibility study report describes several preferred alternative projects, all generally in the Franks Tract area, that would result in enhanced water quality in the Central and South Delta, near the State and federal export pumps, with regards to lowered salinity. None of the preferred alternatives are located on Lower Sherman Island or on Big Break.

The preferred alternatives include:

- West False River Gate Alternative: Add an operable gate across West False River near the confluence with the San Joaquin River (closed on flood tide and partially open on ebb tide)
  - Ecosystem Element: Restoration of marshes on Little Franks Tract pocket marshes in the south, northwest, northeast and east portions of Franks Tract.
  - Recreation Element: Boat navigation locks and four pocket beaches near the pocket marshes. Mooring areas and floating campgrounds could be added.
- North Levee and Two Gates Alternative: Reconstruct the north levee to Old River, construct a gate in the "main nozzle" between False River and Franks Tract; construct a gate on Piper Slough.
  - Ecosystem Element: Restoration of marshes on Little Franks Tract pocket marshes in the south, northwest, northeast and east portions of Franks Tract, and north habitat setback levee along Franks Tract and Little Franks Tract.
  - Recreation Element: Same as above.
- East Levee and Two Gates Alternative: Reconstruct the east levee along Old River and construct gates between Old River and False River, and Old River and Sand Mound Slough, with an option for a third gate option across Old River between the reconstructed levee and Mandeville Island.
  - Ecosystem Element: Restoration of marshes on Little Franks Tract pocket marshes in the south, northwest, northeast and east portions of Franks Tract.
  - Recreation Element: Same as above.
- Cox Alternative: Construct permanent, non-operable flashboard barriers on either side of Quimby Island in Old River and Holland Cut (install June; remove mid-winter).
  - Ecosystem Element: Restoration of marshes on Little Franks Tract pocket marshes in the south, northwest, northeast and east portions of Franks Tract.
  - Recreation Element: Same as above.

Staff has the following preliminary comments:
Installation of barriers to enhance salinity in the Central and South Delta: The water quality of the Delta is key to all the uses of the Delta from water export, to in-Delta agriculture, to aquatic habitat, and to recreation. Enhancement of water quality resulting in lowered salinity in the Central and South Delta will move the region toward the historic, beneficial levels of water quality. The overall goal of the proposed project appears consistent with the Delta Protection Act and the Commission's adopted regional plan.

Project Costs and Responsibility: The feasibility study report describes the cost of construction of each of the several preferred alternatives, but does not include costs of operation and maintenance, nor indicate which entity/agency would be responsible for long term maintenance and operation of the various elements of the project. In other public projects in the Delta, lack of funding for staff and for long-term project management has postponed implementation of projects and programs that would also enhance Delta Primary Zone resources. Estimated long-term costs, including staff and equipment costs, should be included in the cost estimates, along with information about what entity/agency would be responsible.

Ecosystem Element: Each alternative includes creation of about 500 acres of marsh habitat at a cost of about $26 million. In addition, the North Levee and Two Gates Alternative also includes 12,374 linear feet of levee at a cost of an additional $25 million. It is not clear why only one of the alternatives includes the north levee habitat creation. This recommendation should be more fully explained. Costs of long term maintenance should be addressed as noted above. The protection and enhancement of habitat in the Primary Zone is consistent with the Act and the Plan. The proposed project has the added benefit of having no conflict with agriculture.

Recreation: Each alternative ensures that impacts to existing navigable waterways will be mitigated through the installation of appropriate boat lock(s). This is mitigation for the impacts associated with each new physical barrier. New recreation improvements are limited to the four new beaches to be created with each new wetland habitat area. While the document states that other improvements could be installed, there is no specific proposal to do so. The proposed recreation element should be forwarded to the Commission's Recreation Citizens Advisory Committee for review and comment regarding the type and adequacy of the proposed recreation improvements. The RCAC can review the proposed recreation improvements and comment on the amount, type, and location of the proposed recreation enhancements (see attached memo).

The proposed project will be added to the Commission's Pending Projects Memo and updated as new information is available. Please keep the Delta Protection Commission on the interested party mailing list for your planning process, and mail or e-mail any staff reports and meeting agendas.

Please feel free to call if you have any questions regarding these comments.

Sincerely,

Margit Aramburu

Margit Aramburu
Executive Director

Cc: Chairman Mike McGowan
Kathy Kelly, Department of Water Resources
Anthony Perez, Department of Parks and Recreation
Supervisor Mary Piepho
Roberta Goulart, County Planning
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June 24, 2005

Debra Bishop
EDAW Inc.
2022 J Street
Sacramento, CA 95814

Subject: Contra Costa Water District Comments on Flooded Islands Draft Feasibility Study Report

Dear ~~Ms. Bishop~~: Debra

Contra Costa Water District (CCWD) appreciates this opportunity to comment on the Flooded Islands Draft Feasibility Study Report (Report). We commend the California Department of Water Resources, EDAW, and the rest of the consultant team for their work on the innovative, multi-objective projects evaluated in the Report.

CCWD offers the comments below, on issues that should receive particular attention in the next phase of the flooded islands work.

- **Project cost.** Project costs in the $300 million range are higher than anticipated and may be prohibitive. In addition to the recommended pilot project and incremental implementation approach, consideration of ways to reduce full project costs is desirable.

- **Benefit-cost analysis.** As noted in the Report, the benefit-cost analysis is preliminary. Before using this analysis for decision making it should be refined to account for, at a minimum, the differing diversion rates (including total pumping and seasonality) at the various drinking water intakes and the benefits to recreation and the ecosystem.

- **Pilot projects.** The descriptions of pilot projects in Chapter 5 need clarification. For the North Levee and Two Gates alternative, the text description on p. 5-9 seems to imply that the pilot project would include temporary rock barriers across the main nozzle and/or in Piper Slough. The cost estimate in Table 5.3-2 appears to include closure of the jets, but the illustration in Exhibit 5.3-3 does not. For the East Barrier and Two Gates alternative, the text description on p. 5-11 seems to imply that the pilot project would include temporary barriers in east False River and/or Sand Mound Slough, but neither the cost estimate in Table 5.3-3 nor the drawing in Exhibit 5.3-4 show any temporary barriers.

- **Organic carbon.** The ecosystem and water quality objectives of the project may come into conflict over organic carbon concentrations in the Delta. Careful attention should be given to balancing the ecosystem objective of "increased primary productivity in the Western Delta" with drinking water quality concerns about increasing source water concentrations of disinfection by-product precursors.

- **Delta salinity increases.** The four preferred alternatives would all tend to reduce salinity at existing Delta drinking water intakes. However, attention should be given to potential impacts at the locations where these alternatives tend to increase salinity, such as at Emmaton on the Sacramento River, on the San Joaquin River downstream of Jersey Point, and on Middle River.

- **Program development.** Water quality modeling of potential pilot projects should start concurrently with alternatives refinement and optimization, as only alternatives that are associated with workable pilot projects should be carried forward.

If you have any questions regarding these comments, please call me at (925) 688-8083.

Sincerely,

Leah Orloff
Senior Water Resources Specialist

LSO:wec

cc: Dennis Majors, Metropolitan Water District of Southern California
Laura King-Moon, State Water Contractors